TRIZ-based Systematic Innovation Learning System

by

Florence Claire B. Fernandez
Jarrie May C. Lawas
Kurt Romcel B. Oballo
Amilou Jane D. Suarez

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APPROVAL SHEET

This is to certify that we have supervised the preparation of and read the thesis paper prepared by **Florence Claire B. Fernandez, Jarrie May C. Lawas, Kurt Romcel B. Oballo and Amilou Jane D. Suarez** entitled **TRIZ-based Systematic Innovation System** and that the said paper has been submitted for final examination by the Oral Examination Committee.

Felicito S. Caluyo
Thesis Adviser

As members of the Oral Examination Committee, we certify that we have examined this paper and hereby recommend that it be accepted as fulfillment of the thesis requirement for the Degree **Bachelor of Science in Computer Engineering**.

Charmaine Paglinawan
Panel Member 1

Ernesto Vergara Jr.
Panel Member 2

Dionis A. Padilla
Chairman

This thesis paper is hereby approved and accepted by the School of Electrical, Electronics, and Computer Engineering as fulfillment of the thesis requirement for the Degree **Bachelor of Science in Computer Engineering**.

Dr. Felicito S. Caluyo
Dean, School of EECE

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ABSTRACT

The Theory of Inventive Problem Solving or *TeorijaRezhenijaIzobretatelskihZadach* (TRIZ) is a tool, method, and a process for systematic innovation. It has been used in many successful patents, proving that it improves creativity to come up with better ideas. However, as of today, TRIZ is only known by few, in fact most students are not aware of it.This study focuses on deploying the TRIZ program into a hardwareso that it will be a stand-alone learning tool.It also includes a simple game about TRIZ so users will have a better understading on what TRIZ is all about. The study begins by constructing a program to be deployed in hardware down to its testing part where its effectivess will be evaluated.Paired t-test is used as a statistical method to determine whether there is a difference between not using TRIZ and using it through comparing the pre-test and post-test results. Based on the results of the testing done, there is a significant difference between the two and thus, it can be said that the system is effective.

Keywords: TRIZ, C#, .NET Microfamework, Paired t-test

Chapter 1

INTRODUCTION

With the rapid development of technology, innovation has become inevitable. People's need to do things with ease had become necessary. Innovation is doing something different that represents a new opportunity for satisfying wants and needs (Lewitt, 2010). In innovation, problems in the design or in its technological aspects could be encountered. These problems could be solved in different ways. Having 20 problems does not mean that are 20 different solutions. It is possible that different problems could be solved in the same way or one problem could be solved using different solutions.

Problems may exist as a result of contradictions. It means that if you want something to improve, it is likely that something will worsen. An approach known as Systematic Innovation is known as an effective innovation process. It provides tools and techniques to solve many kinds of problems. Among the tools used in Systematic Innovation, Theory of Inventive Problem Solving (TRIZ) is the most widely used.

TRIZ which originated from the term"TeorijaRezhenijaIzobretatelskihZadach" is a Russian phrase which is known as TIPS or "Theory of Inventive Problem Solving" in English. It is a method developed by G.S. Atschuller which is used in problem solving based on logic, data and research and not just by mere intuition. TRIZ research began with the hypothesis that there are universal principles of invention which are the basis for creative innovations and that if these principles could be identified and codified, they could be taught to people to make the process of invention more predictable. Over the last 50 years, the research has proceeded in several stages. Over 2 million patents have been examined, and they found out that only 1500 problems exist. Further studies conclude that out of those 1500 problems, there are only 40 solutions to solve them.

Existing applications for TRIZ are only available with the help of the Internet, which does not consider the fact that some areas do not have access to the Internet.The available resources on the Internet only show the contradiction matrix and the 40 inventive principles but do not show how TRIZ really works. The contradiction matrix is a tool under TRIZ wherein it shows the proper inventive principles to be used to solve the problem when the improving feature and the worsening feature are defined.Also, because materials for systematic innovation, particularly TRIZ are limited, and only few people are familiar with it, a TRIZ-based structured innovation learning system still hasn't been developed.

The main objective of this study is to create a system that will provide a tool for learning and applying TRIZ without the need to access the Internet. The system could be deployed in hardware that is compatible with .NET Framework program.The specific objectives of this study are:

a.) To create a program for TRIZ as a learning tool with a simple game, using .NET Microframework that can be deployed in a stand alone hardware,.

b.) To determine the effectiveness of the system.

The significance of the study is that it can help the people, students and professionals alike, to learn a systematic approach to solve their design or technological problem and not just by random guessing. Since it will be user-friendly, even children can use it and at an early age they will already learn ways to solve design problems which may lead to the possibility of inventing something new. This may lead to the development of one's knowledge and creativity for the advancement technology and new innovation that may result to improving the society. In addition, students and professionals particularly those who are into innovation, could use it as a reference.

The thesis entitled “TRIZ-based Systematic Innovation Learning System” is only limited to TRIZ as a learning tool and will not cover any other kind of method for systematic innovation. Also, the system will not provide an exact solution to the problem but rather a generic solution, it will just give an idea of how the problem will be solved or what to do to solve itbut will never giveany specific answer. For including a simple game, this system will only provide one simple game, while additional games may be expected upon updating the learning tool in the future. The hardware that will be used is a .NET Framework program compatible, and the writers will only design the software but not the hardware.The system will usethe ChipworkX development tool as its hardware. Lastly, the system database can be accessed by the owner of the learning tool but it is not permitted to delete or edit anything on the database.

Chapter 2

Review of Related Literature

Systematic Innovation

Innovation is doing something different that represents a new opportunity for satisfying wants and needs (Lewitt, 2010). Systematic Innovation is an innovation approach for organization that had recognized that they need to have an effective innovation process in order to support their corporate innovation management strategies. It provides a set of tools and techniques that can be applied within a framework to both business development and technical product development and in a manner that can be understood by the non-specialist innovator. Contradiction Elimination, Inventive Principles, Functionality, Ideality, S-Fields, Trends, Time and Space, Trimming and System Completeness are just a few of the tools used in Systematic Innovation. With the tools used in Systematic Innovation, the one which is widely used is TRIZ or the Theory of Inventive Problem Solving.

TRIZ

"Teorija Rezhenija Izobretatelskih Zadach" or TRIZ, a Russian phrase which is known as "Theory of Inventive of Problem Solving" or TIPS in English. It is a proven algorithmic approach to solve system problems and provides a systematic approach for innovation (Lau, 2004). It was developed by GeinrichAtshuller and his colleagues in the former USSR in 1946 and is now being practiced throughout the world (Domb, 2004). After analyzing millions of patents, they found out that each problem contains contradiction.

A contradiction is a conflict in a system and is the core of the most challenging problems (Rantanen and Domb, 2002). Based on the book of Rantanen and Domb, "Simplified TRIZ: New Problem-Solving Applications for Engineers and Manufacturing Professionals", there are two types of contradiction which are trade-off and inherent contradiction. Trade-off is usually the contradiction between the tool and the object. It is when something good happens, something bad also happens. Drinking a cup of hot coffee could be enjoyable (good) but could burn the person drinking (bad) is an example of a trade-off. Inherent contradiction, on the other hand, is usually the contradiction within the tool or object. It is two opposite features or properties in a thing. An example of this is a coffee should be hot for enjoyable drinking but should be cold for it not to burn the person drinking. To develop something, conflicts which exist in them should be resolved.

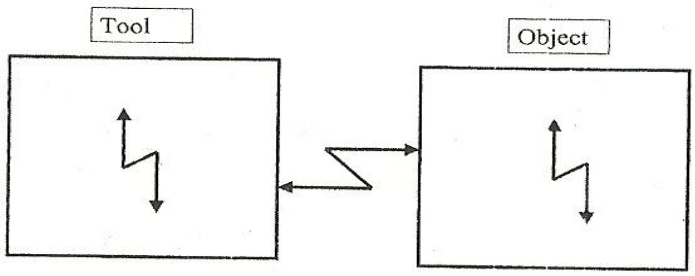

Figure 1 Conflicts Within (inherent contradiction) and Between (trade-off) components (Rantanen and Domb, 2002).

All systems are built from tools and objects. The tool is the component that is easiest to change when the problem is resolved. The object, on the other hand, gives constraints for the change of the tool. Action means that the tool does something that causes the object to change. (Rantanen and Domb, 2002)

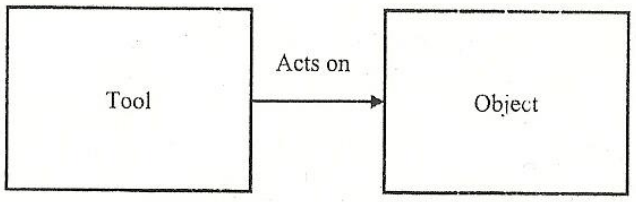

Figure 2 Diagram of Tool, Action, and Object in a System.

Atshuller's 40 Principles of Problem Solving and Contradiction Matrix (1969) are widely used tools under TRIZ. The contradiction matrix is used to be able to choose proper inventive principles when the contradictions have been defined. The matrix has 39 features which could be improved and 39 same features in which the performance can deteriorate. At the intersection of each feature, the suggested principles that could be used to solve the contradiction are found. The principles shown in the intersection are those with the highest probability of resolving the contradiction based on historical analysis (Rantanen and Domb, 2002).

Table 1 Contradiction Matrix (Gequn and Weiguo, 2006)

parameters			Parameters deteriorated					
			1	2	3	4	…	39
Parameters improved	1	Weight of a mobile object			15,8, 29,34		…	35,3, 24,37
	2	Weight of a stationary object				10,1, 29,35	…	1,28, 15,35
	3	Length of a mobile object	8,15, 29,34				…	14,4, 28,29
	4	Length of a stationary object		35,28 40,29			…	30,14 , 7,26
	⋮	⋮	⋮	⋮	⋮	⋮		⋮
	39	Capacity/ productivity	35,26 24,37	28,27 15,3	18,4, 28,38	30,7, 14,26	…	

The problem can be solved using one principle or more. One principle might give you a solution but using several together may be necessary to get to a practical working solution.

Table 2 The 40 Principles of Problem Solving (Rantanen and Domb, 2002)

1	Segmentation (fragmentation)		21	Hurrying (skipping, rushing through)
2	Separation (taking out, extracting)		22	“Blessing in disguise” (convert harm into benefit)
3	Local Quality		23	Feedback
4	Symmetry change (asymmetry)		24	Intermediary (mediator)
5	Merging (consolidation)		25	Self-service
6	Multifunctionality (universality)		26	Copying
7	“Nested doll” (Nesting, Matrushka)		27	Cheap disposables
8	Weight Compensation (anti-weight, counterweight)		28	Mechanical interaction substitution (use of fields)
9	Preliminary counteraction (preliminary anti-action, prior counteraction)		29	Pneumatics and hydraulics
10	Preliminary action (prior action, do it in advance)		30	Flexible shells and thin films
11	Beforehand compensation (beforehand cushioning, cushion in advance)		31	Porous materials
12	Equipotentiality (bring things to the same level)		32	Optical property changes (changing of color)

13	"The other way around" (do it in reverse, do it inversely)		33	Homogeneity
14	Curvature increase (spheroidality, spheroidality-curvature)		34	Discarding and recovering
15	Dynamic parts (dynamicity, dynamization, dynamics)		35	Parameter changes (transformation of properties)
16	Partial or excessive actions (do a little less)		36	Phase transitions
17	Dimensionality change (another dimension)		37	Thermal expansion
18	Mechanical vibration		38	Strong oxidants (accelerated oxidation)
19	Periodic action		39	Inert atmosphere (inert environment)
20	Continuity of useful action		40	Composite material

Table 3 Explanation of the 39 Features of the Contradiction Matrix (Rantanen and Domb, 2002)

	Title	Explanation
	Moving objects	Objects that can be easily change position in space, either on their own or as a result of external forces. Vehicles and objects designed to be portable are the basic members of this class.
	Stationary objects	Objects that do not change position in space, either on their own or as a result of external forces. Consider the conditions under which the object is being used.
1	Weight of moving object	Mass of the object in gravitational field. Force that the body exerts on its support or suspension.
2	Weight of stationary object	Mass of the object in gravitational field. Force that the body exerts on its support or suspension or on the surface on which it rests.
3	Length of moving object	Any one linear dimension, not necessarily the longest, is considered a length.
4	Length of stationary object	Same
5	Area of moving object	A geometrical characteristics described by the part of a plane enclosed by a line. Part of a surface occupied by the object OR the square measure of the surface, either internal or external, of an object.
6	Area of stationary	Same.

	object	Length x width x height for a rectangular object, height x area for a cylinder, etc.
7	Volume of moving object	Cubic measure of space occupied by the object.
8	Volume of stationary object	Same.
9	Speed	Velocity of an object. Rate of a process or action in time.
10	Force	Force measures the interaction between systems. In Newtonian physics, force = mass x acceleration. In TRIZ, force is any interaction that is intended to change an object's condition.
11	Stress of pressure	Force per unit area. Tension.
12	Shape	External contours, appearance of a system.
13	Stability of object's composition	Wholeness or integrity of the system. Relationship of system's constituent elements. Wear, chemical decomposition and disassembly are all decreases in stability. Increase entropy is decreasing stability.
14	Strength	Extent to which the object is able to resist changing in response to force. Resistance to breaking.
15	Duration of action by a moving object	Time that the object can perform the action. Service life. Mean time between failures is a measure of the duration of action. Durability.
16	Duration of action by a stationary object	Same.
17	Temperature	Thermal condition of the object or system. Loosely includes other thermal parameters, such as heat capacity, that affect the rate of change of temperature.
18	Illumination intensity	Light flux per unit area, also any other illumination characteristics of the system such as brightness, light quality, etc.
19	Use of energy by moving object	Measure of the object's capacity for doing work. In classical mechanics, energy is the product of force x distance. This includes the use of energy provided by the super system (such as electrical energy or heat). Energy required to do a particular job.
20	Use of energy by stationary object	Same.
21	Power	Time rate at which work is performed. Rate of use of energy.

22	Loss of energy	Use of energy that does not contribute to the job being done. Reducing the loss of energy sometimes requires techniques that differ from improving the use of energy, which is why this is a separate category.
23	Loss of substance	Partial or complete, permanent or temporary, loss of some of a system's materials, substances, parts or subsystems.
24	Loss of information	Partial or complete, permanent or temporary, loss of data or access to data in or by a system. Frequently includes sensory data such as aroma, texture, etc.
25	Loss of time	Time is the duration of an activity. Improving the loss of time means reducing the time taken for the activity. "Cycle time reduction" is a common term.
26	Quantity of substance/ quantity of matter	The number or amount of a system's that might be changed fully or partially, permanently or temporarily.
27	Reliability	A system's ability to perform its intended functions in predictable ways and conditions.
28	Measurement accuracy	Closeness of the measured value to the actual value of a property of a system. Reducing the error in a measurement increases the accuracy of the measurement
29	Manufacturing precision	Extent to which the actual characteristics of the system or object match the specified or required characteristics
30	External harm affects the object	Susceptibility of a system to externally generated (harmful) effects.
31	Object-generated harmful factors	A harmful effect reduces the efficiency or quality of the functioning of the object or system, generated by the object or system as part of its operation.
32	Ease of manufacture	Degree of the facility, comfort or effortlessness on manufacturing or fabricating object or system.
33	Ease of operation	Simplicity: the process is NOT easy if requires many people, many steps in the operation, needs special tools, etc. "Hard" process = low yield; "Easy" process = high yield; they are easy to do right.
34	Ease of repair	Quality characteristics such as convenience, comfort, simplicity and time to repair faults, failures or defects in a system.
35	Adaptability or versatility	The extent to which a system or object responds positively to external changes. A system that can be used in multiple ways in a variety of circumstances.
36	Device complexity	Number and diversity of elements and element interrelationships within a system. User may be an element of the system that increases the complexity. The difficulty

		of mastering the system is a measure of its complexity.
37	Difficulty of detecting and measuring	Measuring or monitoring systems that are complex and costly, require much time and labor to set up and use or that have complex relationships between components or components that interfere with each other all demonstrate "difficulty of detecting and measuring". Increasing cost of measuring to satisfactory error is also a sign of increased difficulty of measuring
38	Extent of automation	The extent to which a system or object performs its functions without human interface. The lowest level of automation is the use of a manually operated tool. For intermediate levels, humans program the tool, observe its operation and interrupt or reprogram as needed. For the highest level, the machine senses the operation needed, programs itself and monitors its own operations.
39	Productivity	The number of functions or operations performed by a system per unit time. The time for a unit function or operation. The output per unit time or the cost per unit output.

Problem Solving Tool

Different kinds of problems require different thinking tools and different problem solving tools, operating on the object of the process. The extension of TRIZ to non-technical problems makes the identification of the type of problem, the appropriate tools, and the object of the process somewhat more difficult.(Takahara, 2003).

.NET Micro Framework

The Microsoft .NET Micro Framework is a bootable runtime module that brings the advantages of .NET programming to devices too resource-constrained to run other Microsoft embedded platforms. It is programmed through the C# programming language which is a language under the .NET libraries and Visual Studio deployment and debugging. It does not need an underlying operating system to run. (Thompson and Miller, 2007) The .NET Micro Framework could be downloaded for free under Apache

License 2.0. Different companies like GHI Electronics and Secret Labs make chips and development kits that run under .NET Micro Framework. Modules and development kits like EMX, Chipworkx, FEZ Domino, and Netduino run under the .NET Micro Framework.

The program made in the C# programming language could be deployed to the hardware using .NET Micro Framework Deployment Tool.

SQL (Structured Query Language)

The program needed for the development of TRIZ learning tool required the use of database and SQL is the standard language for accessing and manipulating databases. Based from a book written by Akeel I Din, database is a collection of related data, it is a database because it is a collection of letters that form words.

SQL is sometimes referred to as a non-procedural database language. What this means is that when you issue an SQL command to retrieve data from a database, you do not have to explicitly tell SQL whre to look for the data. It is enough just to tell SQL what data you want to retrieve. This is good because users do not need to have any knowledge of where the data is and how to get it. Older languages used for database requires the user to know what data to retrieve and how to get it unlike SQL. This makes SQL easier to use.

Chapter 3

TRIZ-BASED SYSTEMATIC INNOVATION SYSTEM

Abstract

The Theory of Inventive Problem Solving (TRIZ) is a tool, method, and a process for systematic innovation. It has been used in many successful patents, proving that it improves creativity to come up with better ideas. However, as of today, TRIZ is only known by few, in fact most students are not aware of it. This study focuses on deploying the TRIZ program into a hardware so that it will be a stand-alone learning tool.
It also includes a simple game about TRIZ so users will have a better understading on what TRIZ is all about. The study begins by constructing a program to be deployed in our hardware down to its testing part where the effectivess of it will be looked upon. Paired sample t-test is used as a statistical method to determine whether there is a difference between not using TRIZ and using it through comparing the pre-test and post-test results. Based on the results of the testing done, it shows that there is a significant difference between the two and thus, can say that the system is effective.

Keywords: TRIZ, C#, .NET Microfamework, Paired t-test

Introduction

The Theory of Inventive Problem Solving (TRIZ) is one of the problem-solving tools whichis derived from the study of invention patterns in the global patent literature. Solving design problems could lead to the invention of new systems or product innovation that will contribute in the advancement of technology, not only new systems but it can also help in the refinement of old systems. The purpose of this paper is to develop a user-friendly system with an application of innovative system tools in it and could be deployed in a portable hardware. This would serve as a learning tool that can be updated for future development. This tool could help people to be more optimized, logical and creative in their design.

Methodology

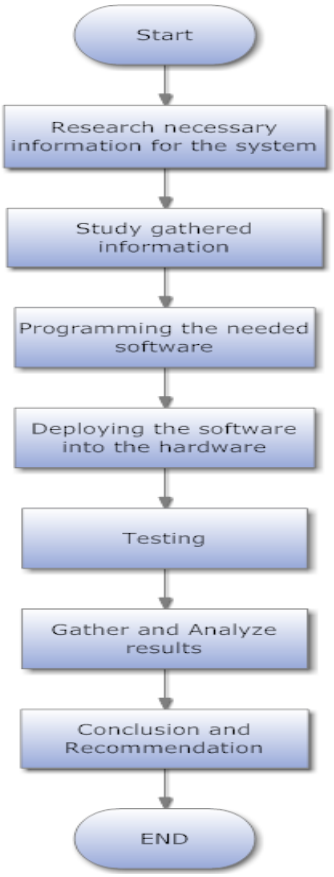

Figure 3 Methodology Flow Chart

Figure 3 shows the summarized methodology of this study through a flow chart.

The first step in this research is the development of the program which will be programmed using Visual Studio .Net Microframework managed by C# code. The information will be accessed through a database that will be displayed in a touch screen LCD screen. To make it user-friendly, certain explanations about how to use it will be included in the program, and examples for the principles will also be cited for the user to understand it better.Figure 4 shows the main flow of the program which consists of five subroutines.

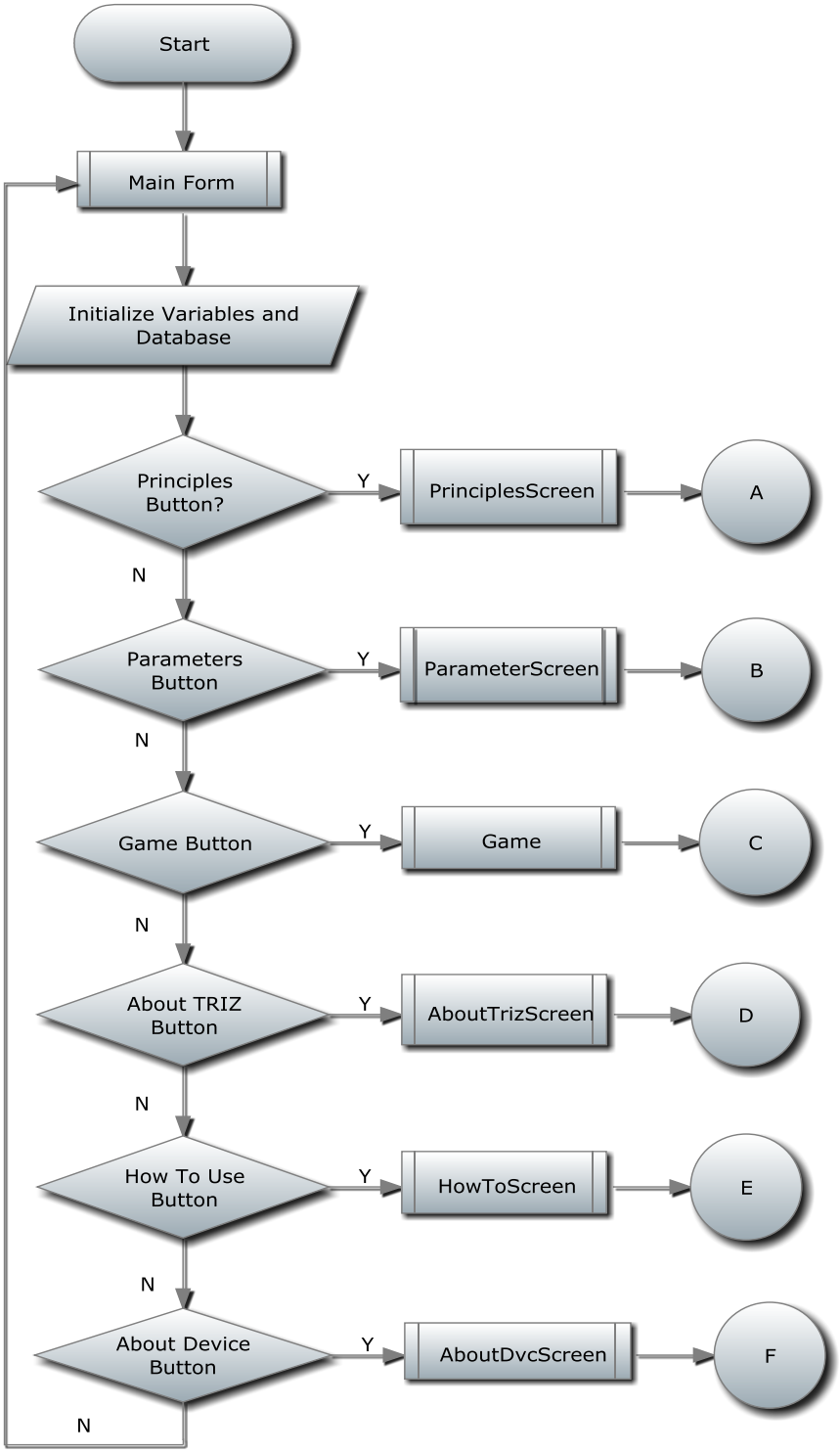

Figure 4 Program Main Flow Chart

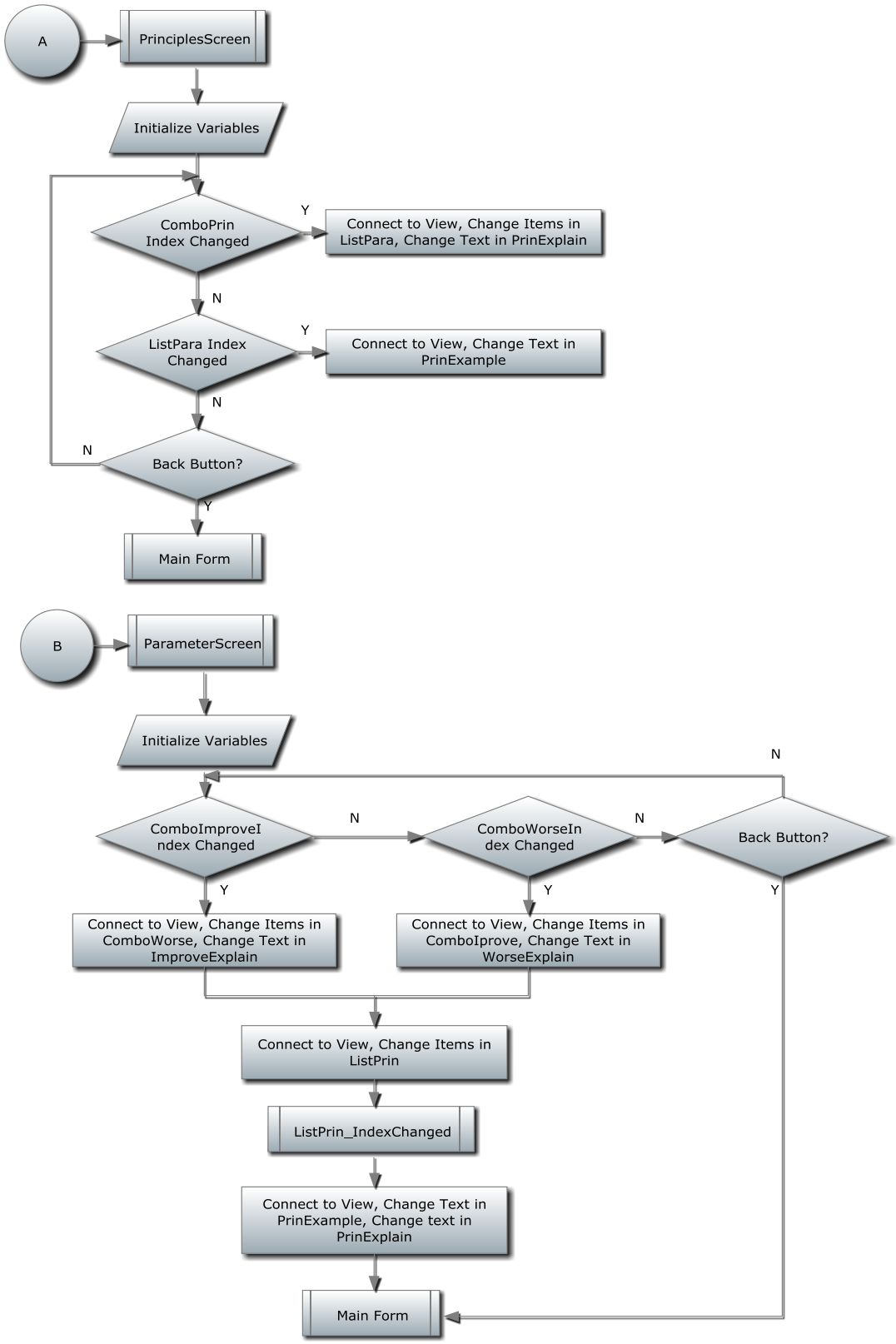

Figure 5 Principle and Parameter Screen Subroutine Flow Chart

Figure 5 is the representation of two of the five routines which are the PrincipleScreen and ParameterScreen. For the PrincipleScreen when the user selects a choice from the combobox it will connect to the database, and the same goes for the list box which is named as ListPara. As for the ParameterScreen, the database will activate when the user selects from the ComboImprove and ComboWorseIn. A list of choice at ListPrin will be shown and if the user chooses one, the database for its explanation will be shown.

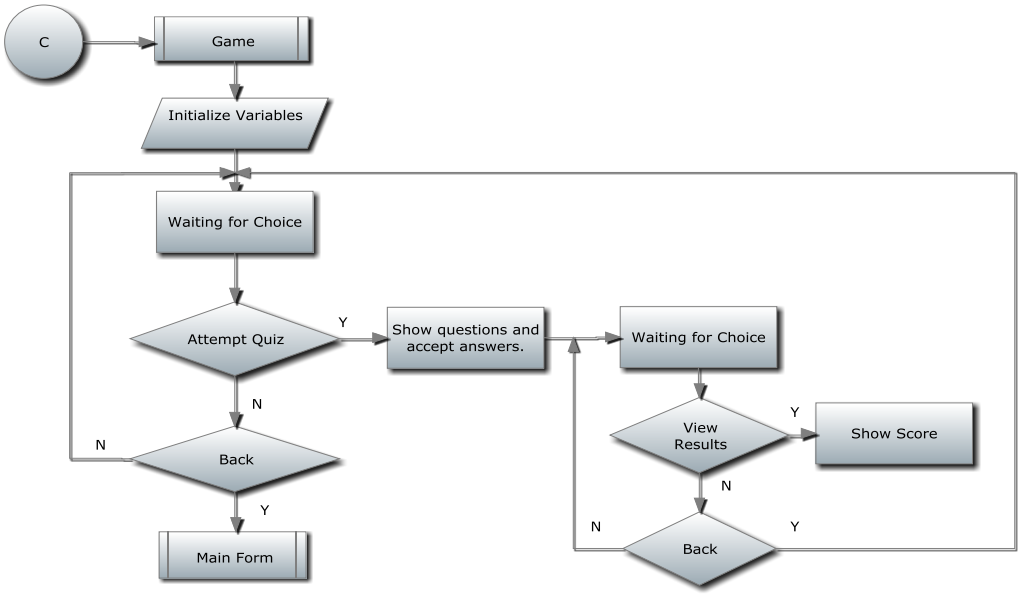

Figure 6 Game Subroutine Flow Chart

Figure 6 above is for the game subroutine, a simple multiple choice game that will make the user understand how TRIZ works. This part will be used for the testing part of the study. When game button is pressed, it will first initialize the form to be used and waits for the user's choice. Attempting quiz means answering the questions and after answering all the questions an option to show the results or to go back will be given.

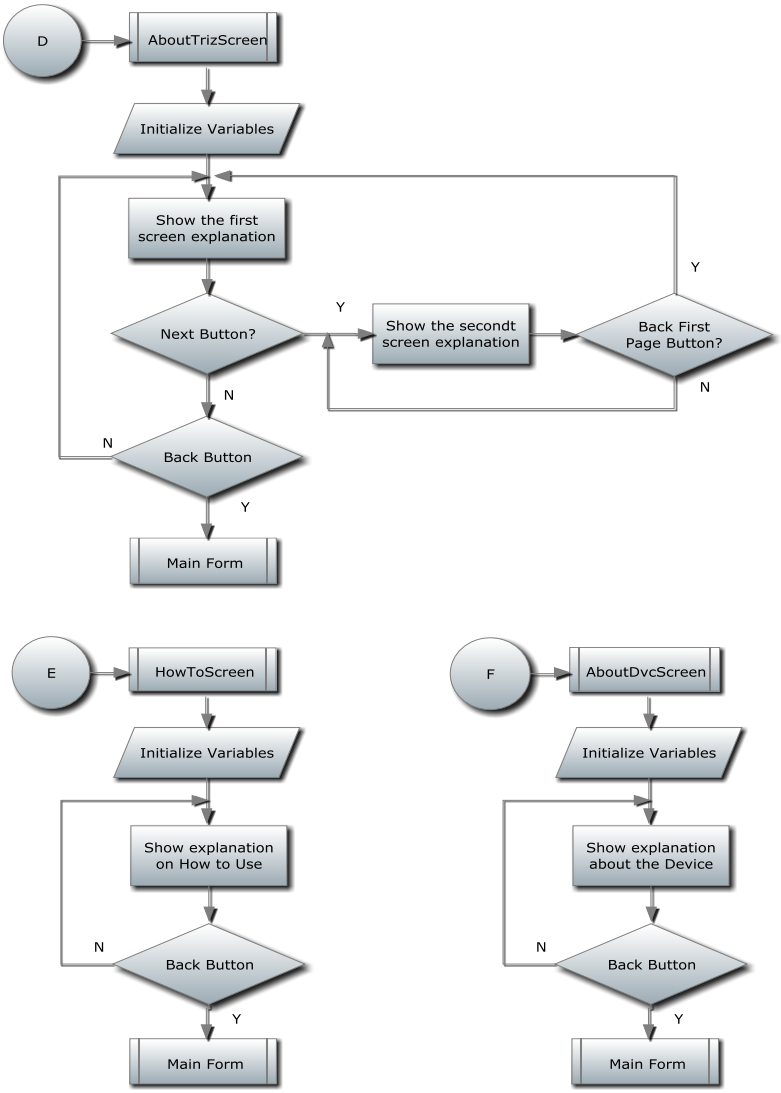

Figure 7 Help Menu Subroutine Flow Chart

Figure 7 consists of the help menu functions. The flow is just simple, such that when a corresponding button is clicked, the explanation will show up. If the user wants to go back to main menu, then he just needs to press the back button.

After the development of the program, the next step is to deploy the program made to the hardware. The main tool in the hardware will be the touch screen LCD screen which will serve as the controller itself as well as where the information will be shown. A

memory card slot may be considered as an additional memory for information stored if needed. In the future, the program maybe updated if further information or updates will be released. There are various development tool that is compatible with .NET Micro Framework. In this paper, ChipworkX development systemwill be used as seen in Figure 8.

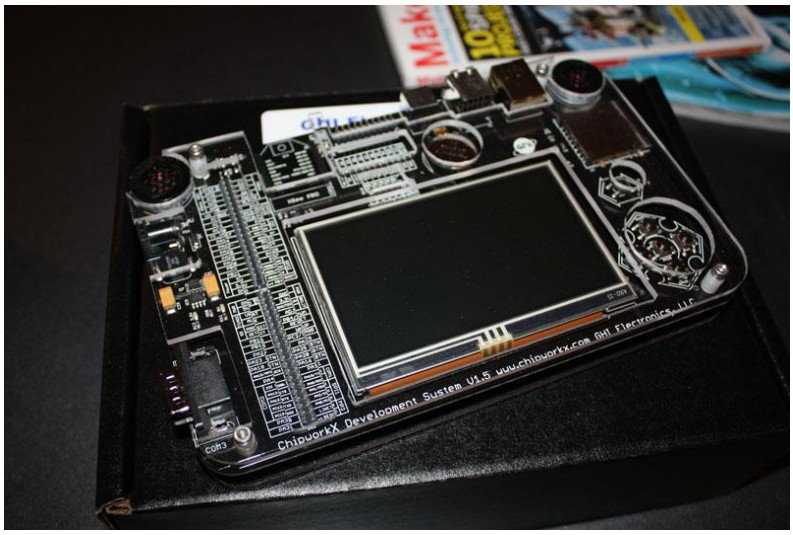

Figure 8 ChipworkX Development System

In testing, a test that also serves as a game,will be conducted on atleast 30 population that is still unaware of TRIZ. They will be first take a pre-test without any knowledge of TRIZ. They will be scored depending on the results of the test after whicha post-test will be given,but this time with the aid of using TRIZ and then again will be scored.

These are the different questions/problems that the test case will solve using the TRIZ learning tool:

1. Using the Contradiction Matrix, an improving factor “realibility”, anda worsening factor of “power” were identified. Which of the following is the principle which should be investigated first?

2. In designing a rotating cutting machine, a powerful but low 100 rpm motor is required. Since most AC motors are high rpm (3600 rpm), the analogous standard problem is how to reduce the speed of the motor.
3. Principle #2 , taking out, means separating a part or property of an object, which of the following is not an example of it?
4. For job hunters, instead of sending out generic resumes, tailor each resume to each particular company and job description. This is an example of what principle?
5. A certain car needs to be repaired in order to gain back its speed. If speed is an improving parameter and the ease of repair is the worsening, what must you do?
6. Having a dog is not your thing, but you are in need of it to scare away thieves, what must you do?
7. You have to cook several dishes because a party will be held in your house, you need to cook all dishes in just an hour, how will you cook faster without exerting too much additional effort?
8. You will join a race for remote controlled toy cars; you have bought a car smaller than the requirement because it was much faster than bigger cars. How can you improve your car volume without affecting its speed?
9. You want to improve the strength of your boat, but adding more materials will make it heavier, how can you improve your boat without making it heavier?
10. A town square was turned into a playground for children. At the same time it was impossible to bar the traffic in an adjoining street. This gave rise to a

problem: is it possible to make motorists slow down while driving past the playground? Two proposals were put forth: covering a part of the street with a zebra crossing or giving this section of the road a zigzag profile. The first way was cheap but had a restricted effect, the second was safe but expensive. The desired solution should combine the advantages but be devoid of the disadvantages. What would you suggest?

The statistical treatment to be used is the paired t-test which will compare the means of the post and pretest results of the test and see of the average difference is significantly different from zero. Our null hypothesis is that there is no significant difference between the two variables and, the alternate hypothesis will be there is a significant difference between the two variables.

First is to let x = test scores without TRIZ and y=test scores with TRIZ then, calculate the difference

$$d_i = y_i - x_i (3.1)$$

between the two scores on each pair. After having the difference, compute for the mean difference $\bar{d}$ by adding all the differences then dividing by n, number of pairs.

Next step is to calculate the standard deviation of differences that will be used for the calculation of standard error of the mean difference.

$$s_d = \sqrt{\frac{\sum\{d_i - \bar{d})^2}{n-1}} (3.2)$$

$$SE(d) = \frac{s_d}{\sqrt{n}} \quad (3.3)$$

It will also be required to compute for the t-statistic which is given by:

$$T = \frac{\bar{d}}{SE(d)} \quad (3.4)$$

This statistics follows a t-distribution with $n - 1$ degrees of freedom. Using the tables of t-distribution (see Appendix E), the value for T will be compared to the t_{n-1}distribution with a p value of 0.05.

Results and Discussion

In testing the design, respondents were randomly chosen and most of them were college students. Table 4 shows the scores obtained by the testers when they are still unaware of TRIZ (score without TRIZ) and when they have the use of the tool (score with TRIZ.

Table 4 Tallied Scores for the paired sample T-test

Testers	**Score without TRIZ** x	**Score with TRIZ** y	**Difference** d_i
1	5	5	0
2	5	7	2
3	6	8	2
4	4	8	4
5	2	5	3
6	4	5	1
7	4	8	4
8	2	6	4
9	3	8	5
10	6	7	1
11	3	5	2
12	3	6	3
13	7	7	0
14	5	8	3
15	2	6	4
16	4	5	1
17	2	5	3
18	6	7	1
19	3	6	3

20	5	4	-1
21	3	5	2
22	5	7	2
23	5	8	3
24	4	5	1
25	6	8	2
26	4	6	2
27	6	6	0
28	5	9	4
29	7	8	1
30	2	7	5
31	3	6	3
32	2	5	3
33	6	7	1
34	4	5	1
35	5	8	3
36	7	9	2
37	3	7	4
38	3	5	2
39	2	6	4
40	6	7	1
TOTAL	169	260	91
Mean	4.225	6.5	2.275
Standard Deviation	1.5769	1.3205	1.4498

Using the data on Table 3.1, computing for the mean difference $\bar{d} = {}^{91}/_{40}$ giving the value of $\bar{d} = 2.275$. With the value of mean difference, and the standard deviation of difference $s_d = 1.4498$. Therefore, $SE(d) = \frac{1.4498}{\sqrt{40}} = 0.2292$.

So we have: $T = \frac{2.275}{0.2292}$= 9.924 on 39 df, looking up at the table with $p = 0.05$, t_{n-1}=2.04. Table 5 shows the tabulated statistics results from the computations made.

Table 5 Tabulated Statistics Results

Mean Difference,$\bar{d}$	**Standard Deviation of Difference, s_d**	**Standard Error of the Mean Difference, $SE(d)$**	**T-statistic, T**	**T value frp, t-table, t_{n-1}**
2.275	1.4498	0.2292	9.924	2.04

Conclusion

According to the results obtained, there is a significant difference between not using TRIZ and using it. It can therefore be concluded that the system that was designed and implemented is effective in thinking and solving in a systematic way.

Chapter 4

CONCLUSION

At the end of the research, a stand alone TRIZ learning tool was created using .NET Microframework with C# programming language. Aside from having a TRIZ-based systematic learning system, a simple game was also included in the learning tool. The simple game that the designers included aims to help the users to fully understand how TRIZ could be applied, or how can they can use it to solve problems. The designers specifically chose a quiz game where the questions/problems are all situations, are related to innovating something in which they can apply the TRIZ concept. Through this, the users can enjoy and further understand what TRIZ is all about. The data are accessible through the use of database.

With regards to the hardware part, there are times that processing is slow due to the limitations brought about by the hardware capability. Future improvements can consider hardware upgrades such as increasing memory storage.

In solving problems or innovating something using TRIZ, users must identify the improving factor and the worsening factor that they think may deteriorate upon refining the feature they want to improve. This may be the only thing that users need to identify in order to answer the problems and TRIZ could give ideas and answers on how to improve something and solve problems without damaging this worsening factor.

Results of the testing show that upon learning how to use TRIZ, people also improve the way they answer problems. The score of the participants before and after learning TRIZ shows significant change. This means that using TRIZ is an effective way

to help people solve problems easier and more accurately. They could easily think of an answer through the idea that TRIZ had given them.

All in all, “TRIZ-based Systematic Innovation Learning System” tool is considered as an effective learning tool of TRIZ, which may help in helping the user to form new ideas in a systematic way. Through further developments, it could be easy to be used by anyone who is interested. This could also help scientists, inventors and enthusiasts to innovate current technologies for the upcoming generations.

Chapter 5

RECOMMENDATION

There are factors that need to be improved in this study. First is the hardware since the memory capacity of the hardware may not be enough for future updates. It is also recommended to have a better LCD touch screen for the ease of use. Designs on the program may also be developed to make it more interesting.

It would be advisable to add sounds and creative animations if the memory can still handle it, sothat children will have fun using it. Addition of games for more enjoyment may also be made.

As for the content, additional methods in solving and learning are recommended to be added with various examples.

For future development, additional materials may be included in the database to create new solutions to problems and also show technology development in the Philippines.

It was also good to add some applications in the learning tool such as PDF readers, other related games, and other applications that could help people to learn.

Lastly, since smartphones are in right now, it was also good to develop a TRIZ-based application that could run in smartphones for those enthusiasts who want to use their smartphones for it.

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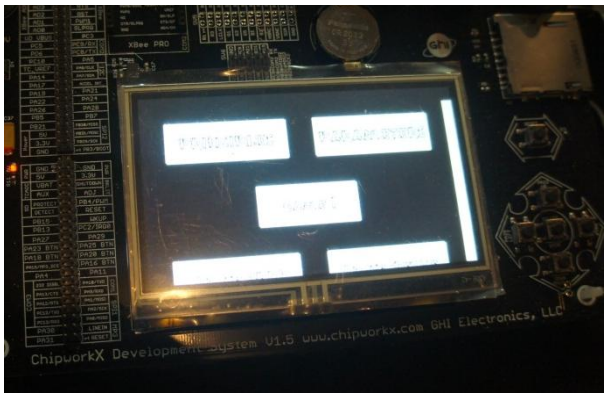
APPENDIX A

Operation's Manual

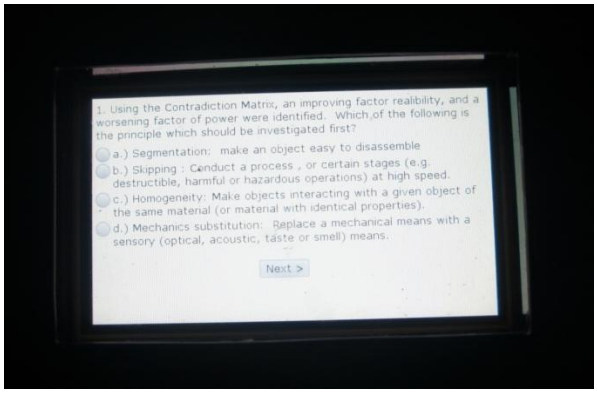
User's Manual

1. Plug a 7V adaptor to the hardware or use a battery to switch it on.
2. After inserting the power supply the system will automatically run and boot. On system boot up, this message will be shown:

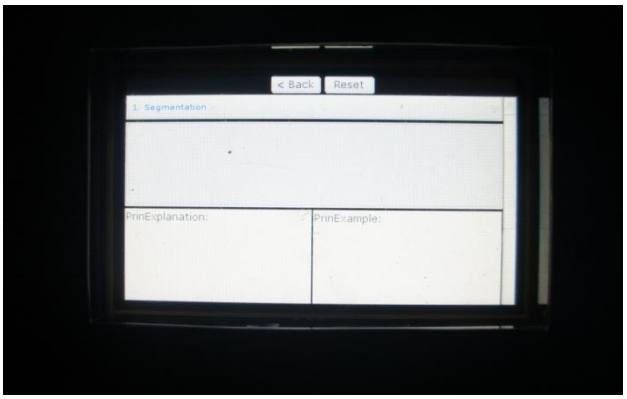
3. After the boot up, a menu will be automatically displayed.
4. Select the operation you desired to do e.g. to play a game, to use TRIZ, to see the principles and parameters and ask about TRIZ/ how to use system, you can use your finger or stylus to select (The hardware has a TFT LCD and could be operated using your finger or a stylus). The figure below shows the menu page.



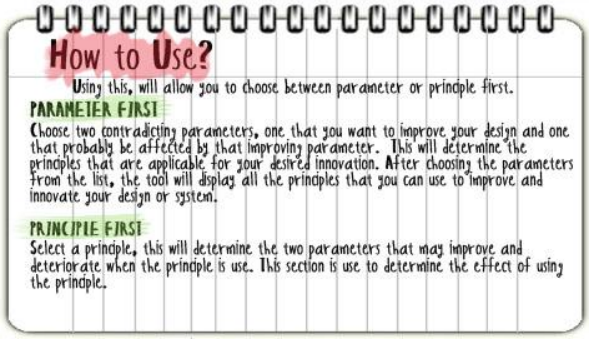
5. When you choose to play a game, you will play a quiz like game, which is answerable by applying TRIZ, the figure below is an example.

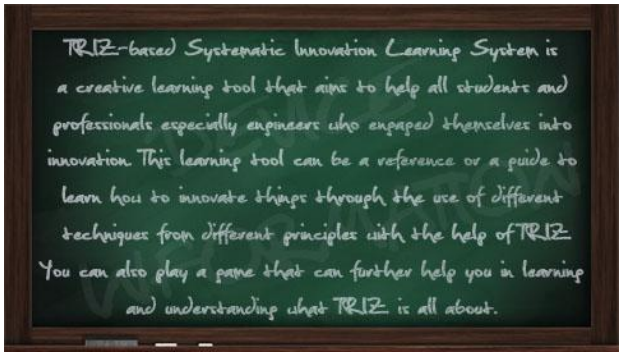


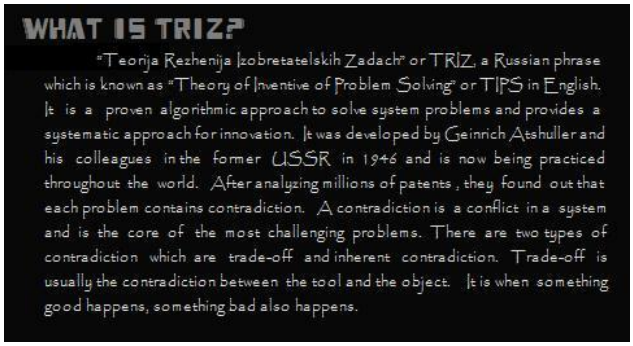
6. For parameters and principles, the image below shows how it was displayed.

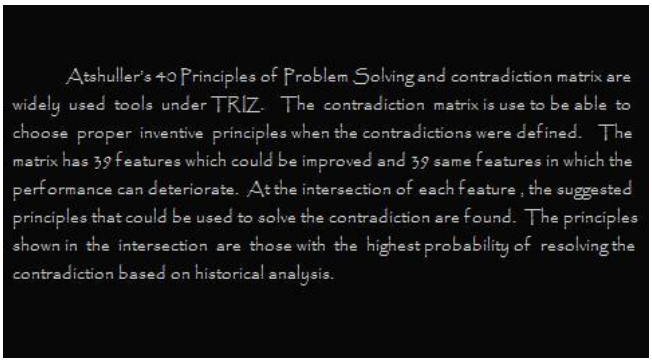


7. The following images will be displayed when you choose “How to Use” and “About TRIZ”









8. Enjoy using the learning tool for TRIZ!

Troubleshooting Guides and Procedures

1. If the system hangs, or any other error in the software occurred, you can use the emergency reset button at the right side of the learning tool.
2. If the system just turned off automatically make sure that it has enough power supply or if the battery needs to be replaced.

APPENDIX B

Program Listing

```
using System;
using Microsoft.SPOT;
using Skewworks.NETClix;
using BreakContinue.Data.SQLite;

namespace Thesis_DOTNETClix
{
    public class Program
    {
        #region Variables

        private static Form formMain;           // Main form
        private static Transitions RetTrans;    // Transition to Main form

        public static SQLiteCommand cmd;
        public static SQLiteConnection connection;
        public static SQLiteDataReader reader;

        public static int i = 0;

        public static Combobox comboPrin;
        public static Combobox comboImproveParam;
        public static Combobox comboWorseParam;
        public static Listbox listPara;
        public static Form formPrinFirst;
        public static CommandButton backMenu;

        static string[] paramexplain = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39" };
        static string[] prinparams = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };
        static string[] prinExplainA = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40"
};//Resources.GetString(Resources.StringResources.prinExA).Split('/');
        static string[] prinExplainB = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };
        static string[] prinExplainC = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };
        static string[] prinExplainD = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };
        static string[] prinExplainE = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };
```

```
        static string[] prinExampleA = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };
        static string[] prinExampleB = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };
        static string[] prinExampleC = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };
        static string[] prinExampleD = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };
        static string[] prinExampleE = new string[] { "", "1", "2", "3", "4", "5",
"6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19",
"20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33",
"34", "35", "36", "37", "38", "39", "40" };

        static string[] para =
Resources.GetString(Resources.StringResources.literalPara).Split(';');
        static string[] prin =
Resources.GetString(Resources.StringResources.literalPrin).Split(';');
        static Font burnstown =
Resources.GetFont(Resources.FontResources.burnstown);



        #endregion

        public static void Main()
        {
            // Create main form
            formMain = new Form(Colors.Black);
            formMain.Font = Fonts.Verdana10;
            formMain.AutoScroll = true;

            Initialize();

            //Buttons on menu page
            CommandButton prinFirst = new CommandButton("PRINCIPLES", 35, 40, 180,
60);
            CommandButton paraFirst = new CommandButton("PARAMETERS", 255, 40, 180,
60);
            prinFirst.Font = burnstown;
            paraFirst.Font = burnstown;
            formMain.AddChild(prinFirst);
            formMain.AddChild(paraFirst);
            prinFirst.Tap += new OnTap((object sender, point e) =>
PrincipleScreen());
            paraFirst.Tap += new OnTap((object sender, point e) =>
ParameterScreen());

            //Game part
            CommandButton game1 = new CommandButton("Game 1", 161, 140, 150, 60);
            game1.Font = burnstown;
```

```
            formMain.AddChild(game1);
            game1.Tap += new OnTap((object sender, point e) => gameStart1()); ;

            //Help part
            CommandButton mhAbtTriz = new CommandButton("About TRIZ", 35, 240, 180,
60);
            mhAbtTriz.Font = burnstown;
            formMain.AddChild(mhAbtTriz);
            mhAbtTriz.Tap += new OnTap((object sender, point e) =>
AboutTrizScreen(1));
            CommandButton mhAbtDvc = new CommandButton("About Device", 255, 240,
180, 60);
            mhAbtDvc.Font = burnstown;
            formMain.AddChild(mhAbtDvc);
            mhAbtDvc.Tap += new OnTap((object sender, point e) =>
AboutDvcScreen());
            CommandButton mhHowTo = new CommandButton("How to Use", 161, 310, 150,
60);
            mhHowTo.Font = burnstown;
            formMain.AddChild(mhHowTo);
            mhHowTo.Tap += new OnTap((object sender, point e) => HowToScreen());

            //Activate the form
            Graphics.ActiveContainer = formMain;

           // Graphics.ScreenTransition(formMain, Transitions.FadeBlack);
        }

        #region Principle First

        private static void PrincipleScreen()
        {
            //form
            formPrinFirst = new Form(Colors.Black);
            formPrinFirst.AutoScroll = true;

            //panel
            Panel panParam = new Panel(4, 55, 235, 217,
Skewworks.NETClix.Colors.Wheat);
            formPrinFirst.AddChild(panParam);
            Panel panExam = new Panel(245, 125, 235, 147,
Skewworks.NETClix.Colors.Wheat);
            formPrinFirst.AddChild(panExam);
            Panel panEx = new Panel(245, 20, 235, 100,
Skewworks.NETClix.Colors.Wheat);
            formPrinFirst.AddChild(panEx);

            backMenu = new CommandButton("< Back", 180, 280, 60, 30);
            formPrinFirst.AddChild(backMenu);
            backMenu.Tap += new OnTap((object sender, point e) => ShowMainForm());
            RetTrans = Transitions.SlideRight;

            CommandButton reset1 = new CommandButton("Reset", 245, 280, 60, 30);
            formPrinFirst.AddChild(reset1);

            //listbox
            listPara = new Listbox(5, 56, 233, 215, false);
            formPrinFirst.AddChild(listPara);
```

```
            //comobobox
            comboPrin = new Combobox(4, 20, 235, Fonts.Verdana8,prin);
            formPrinFirst.AddChild(comboPrin);

            //event handler
            comboPrin.SelectedIndexChanged += new
OnSelectedIndexChange(comboPrin_SelectedIndexChanged);
            comboPrin.ForeColor = Skewworks.NETClix.Colors.Blue;

            Graphics.ScreenTransition(formPrinFirst, Transitions.FadeBlack);
        }

        static void comboPrin_SelectedIndexChanged(object sender, int index)
        {
            string prinIndex;
            prinIndex = comboPrin.SelectedIndex.ToString();

            try
            {
                cmd = new SQLiteCommand("SELECT PrinID, Prin1, Worse, Improve FROM
View", connection);
                reader = cmd.ExecuteReader();

                while (reader.Read())
                {
                    if (prinIndex == reader[0].ToString())
                    {
                        listPara.AddItem("" + reader[2].ToString() + "/" +
reader[3].ToString());
                    }
                }
            }
            catch (Exception ex)
            {
                Dialogs.Prompt("Connection Error", "Error", PromptType.OKOnly);
            }
        }

        #endregion

        #region Parameter First
        static Form formParaFirst;
        static Combobox cmbiPara;
        static Combobox cmbwPara;
        static Listbox listPrin;
        private static void ParameterScreen()
        {
            formParaFirst = new Form(Colors.Black);
            formParaFirst.AutoScroll = true;

            cmbiPara = new Combobox(4, 30, 235, Fonts.Verdana8, para);
            cmbwPara=new Combobox(4, 240, 235,Fonts.Verdana8,para);
            formParaFirst.AddChild(cmbwPara);
            formParaFirst.AddChild(cmbiPara);
            Panel exIPara = new Panel(4, 65, 235, 150, Colors.Wheat);
            Panel exWPara = new Panel(4, 275, 235, 150, Colors.Wheat);
            Panel explanation = new Panel(245, 240, 235, 185, Colors.Wheat);
```

```
            Panel examples = new Panel(4, 450, 480, 125, Colors.Wheat);
            formParaFirst.AddChild(exIPara);
            formParaFirst.AddChild(exWPara);
            formParaFirst.AddChild(explanation);
            formParaFirst.AddChild(examples);
            listPrin = new Listbox(245, 30, 235, 185, false);
            formParaFirst.AddChild(listPrin);
            CommandButton backMenu1 = new CommandButton("< Back", 180, 585, 60,
30);
            CommandButton reset2 = new CommandButton("Reset", 245, 585, 60, 30);
            formParaFirst.AddChild(backMenu1);
            formParaFirst.AddChild(reset2);
            backMenu1.Tap += new OnTap((object sender, point e) => ShowMainForm());
            RetTrans = Transitions.SlideRight;
            Graphics.ScreenTransition(formParaFirst, Transitions.FadeBlack);

        }
        #endregion

        #region Game1
        static void gameStart1()
        {
            Form frm = new Form();
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            frm.AddChild(new Label("The TRIZ Quiz!", 113,70));
           // frm.AddChild(new CommandButton("Proceed", 160, 160, 100,30));

            /*Textbox nameBox = new Textbox(" ", 4, 80, frm.Width - 100,
Fonts.Verdana10.Height + 5);
            frm.AddChild(nameBox);
            string textname = nameBox.Text;*/
            CommandButton proceed = new CommandButton("Attempt
Quiz?",110,118,100,30);
            proceed.Tap +=new OnTap((object sender, point e) => QuizPrompt());
            frm.AddChild(proceed);

            CommandButton cmdBack = new CommandButton("< Go Back", 200, 200, 100,
25);
            cmdBack.Tap += new OnTap((object sender, point e) => ShowMainForm());
            frm.AddChild(cmdBack);

            // Set the return transition
            RetTrans = Transitions.SlideRight;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeBlack);

        }

        private static void QuizPrompt()
        {
            Form frm = new Form();

            if (Dialogs.Prompt("Are you sure you want to start the quiz?", "TRIZ
Quiz", PromptType.YesNo) == PromptResult.Yes)
            {
```

```
                Dialogs.Prompt("Good Luck!", "TRIZ Quiz", PromptType.OKOnly);
                TestPage();
            }
            else
                gameStart1();
        }
       //int x=0,z=0,y=0;


        private static void TestPage()
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            int x = 0, z = 0;

            //q1

            Label lab = new Label("1. What principle should be considered in order
to determine the characteristic of a bendy drinking straw?", 4, 5, 300, 250);
            frm.AddChild(lab);
            RadioButton ans = new RadioButton(4, 60,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
            RadioButton ans2 = new RadioButton(4, 80,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 100,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
            RadioButton ans4 = new RadioButton(4, 120,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("Nested Doll", 25, 60, 200, 25));
            frm.AddChild(new Label("Dynamics", 25, 80, 200, 25));
            frm.AddChild(new Label("Flexible Shells and Thin Films", 25, 100, 200,
25));
            frm.AddChild(new Label("None of the above", 25, 120, 200, 25));
            ans.Tap += new OnTap((object sender, point e) => x = 0);
            ans2.Tap += new OnTap((object sender, point e) => x = 1);
            ans3.Tap += new OnTap((object sender, point e) => x = 0);
            ans4.Tap += new OnTap((object sender, point e) => x = 0);

            CommandButton but1 = new CommandButton("Next >", 200, 200);
            frm.AddChild(but1);
            if (x <= 1)
            {
            but1.Tap += new OnTap((object sender, point e) => TestPage2(0,z+=x));
            }
            else
                TestPage();

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
```

```
        }

        private static void TestPage2(int x ,int z)
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;


            //q2
            frm.AddChild(new Label("2. What does TRIZ stand for?", 4, 5, 300,
250));
            RadioButton ans = new RadioButton(4, 40,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
            RadioButton ans2 = new RadioButton(4, 80,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 120,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
            RadioButton ans4 = new RadioButton(4, 160,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("Teoriya Rishenaya Izobretatelskikh Zadach", 25,
40, 250, 50));
            frm.AddChild(new Label("Teoriya Resheniya Izobretatelskikh Zadach", 25,
80, 250, 50));
            frm.AddChild(new Label("Teoriya Resheniya Isobretatelskikh Zadack", 25,
120, 250, 50));
            frm.AddChild(new Label("Theoriya Reshemiya Izobretatelskikh Zadach",
25, 160, 250, 50));
            ans.Tap += new OnTap((object sender, point e) => x=0);
            ans2.Tap += new OnTap((object sender, point e) => x=1);
            ans3.Tap += new OnTap((object sender, point e) => x = 0);
            ans4.Tap += new OnTap((object sender, point e) => x = 0);


            CommandButton but1 = new CommandButton("Next >", 200, 200);
            frm.AddChild(but1);
            if (x <= 1)
            {
                but1.Tap += new OnTap((object sender, point e) => TestPage3(0, z +=
x));
            }
            else
                TestPage2(x,z);
            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
        }
        //but1.Tap += new OnTap((object sender, point e) => Dialogs.Prompt("You've
scored " + (z + x), "TRIZ QUIZ", PromptType.OKOnly));
        private static void TestPage3(int x,int z)
        {
            Form frm = new Form(Colors.White);
```

```
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            //q3
            Label lab = new Label("3. which of the following statements is true
about TRIZ?", 4, 5, 300, 250);
            frm.AddChild(lab);
            RadioButton ans = new RadioButton(4, 40,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
            RadioButton ans2 = new RadioButton(4, 100,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 160,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
            RadioButton ans4 = new RadioButton(4, 220,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("It presents a dynamic approach for analysing
the kind of challenging problems where inventiveness is needed.", 25, 40, 250,
50));
            frm.AddChild(new Label("It was developed on a foundation of extensive
research covering hundreds and thousands of products.", 25, 100, 250, 50));
            frm.AddChild(new Label("It involves contradictions which is essential
in developing inventive solutions.", 25, 160, 250, 50));
            frm.AddChild(new Label("It is typically known as the \"Theory of
Innovative Problem Solving\"", 25, 220, 250, 50));
            ans.Tap += new OnTap((object sender, point e) => x = 0);
            ans2.Tap += new OnTap((object sender, point e) => x = 0);
            ans3.Tap += new OnTap((object sender, point e) => x = 1);
            ans4.Tap += new OnTap((object sender, point e) => x = 0);


            CommandButton but1 = new CommandButton("Next >", 200, 260);
            frm.AddChild(but1);
            if (x <= 1)
            {
                but1.Tap += new OnTap((object sender, point e) => TestPage4(0, z +=
x));
            }
            else
                TestPage3(x,z);

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
        }
        private static void TestPage4(int x, int z)
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            //q4
```

```
            Label lab = new Label("4. What is the correct pattern for analyzing
problems?", 4, 5, 300, 250);
            frm.AddChild(lab);
            RadioButton ans = new RadioButton(4, 40,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
            RadioButton ans2 = new RadioButton(4, 80,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 120,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
            RadioButton ans4 = new RadioButton(4, 160,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("General Problem - General Solution - Specific
Problem - Specific Solution", 25, 40, 250, 50));
            frm.AddChild(new Label("Specific Problem - Specific Solution - General
Problem - General Solution", 25, 80, 250, 50));
            frm.AddChild(new Label("Specific Problem - General Problem - General
Solution - Specific Solution", 25, 120, 250, 50));
            frm.AddChild(new Label("General Problem - Specific Solution - Specific
Problem - General Solution", 25, 160, 250, 50));
            ans.Tap += new OnTap((object sender, point e) => x = 0);
            ans2.Tap += new OnTap((object sender, point e) => x = 0);
            ans3.Tap += new OnTap((object sender, point e) => x = 1);
            ans4.Tap += new OnTap((object sender, point e) => x = 0);

            CommandButton but1 = new CommandButton("Next >", 200, 200);
            frm.AddChild(but1);
            if (x <= 1)
            {
                but1.Tap += new OnTap((object sender, point e) => TestPage5(0, z +=
x));
            }
            else
                TestPage4(x, z);

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
        }
        private static void TestPage5(int x, int z)
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            //q5
            Label lab = new Label("5. Which of the following examples follows the
\"Another Dimension Principle\"", 4, 5, 300, 250);
            frm.AddChild(lab);
            RadioButton ans = new RadioButton(4, 40,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
```

```
            RadioButton ans2 = new RadioButton(4, 60,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 80,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
            RadioButton ans4 = new RadioButton(4, 100,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("Individually wrapped cheese slices.", 25, 40,
250, 25));
            frm.AddChild(new Label("\"Adult\" editions of Harry Potter books.", 25,
60, 250, 25));
            frm.AddChild(new Label("Store within store.", 25, 80, 250, 25));
            frm.AddChild(new Label("Squeezable ketchup bottles that sit on their
lids.", 25, 100, 250, 50));
            ans.Tap += new OnTap((object sender, point e) => x = 0);
            ans2.Tap += new OnTap((object sender, point e) => x = 0);
            ans3.Tap += new OnTap((object sender, point e) => x = 0);
            ans4.Tap += new OnTap((object sender, point e) => x = 1);

            CommandButton but1 = new CommandButton("Next >", 200, 200);
            frm.AddChild(but1);
            if (x <= 1)
            {
                but1.Tap += new OnTap((object sender, point e) => TestPage6(0, z +=
x));
            }
            else
                TestPage5(x, z);

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
        }
        private static void TestPage6(int x, int z)
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            //q6
            Label lab = new Label("6. \"Training is comprehensive, but keeps
employees away from their assignments\". What type of contradiction is shown?", 4,
5, 300, 250);
            frm.AddChild(lab);
            RadioButton ans = new RadioButton(4, 60,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
            RadioButton ans2 = new RadioButton(4, 80,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 100,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
```

```
            RadioButton ans4 = new RadioButton(4, 120,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("Technical Contradiction.", 25, 60, 250, 25));
            frm.AddChild(new Label("Social Contradiction.", 25, 80, 250, 25));
            frm.AddChild(new Label("Physical Contradiction.", 25, 100, 250, 25));
            frm.AddChild(new Label("None of the above.", 25, 120, 250, 25));
            ans.Tap += new OnTap((object sender, point e) => x = 1);
            ans2.Tap += new OnTap((object sender, point e) => x = 0);
            ans3.Tap += new OnTap((object sender, point e) => x = 0);
            ans4.Tap += new OnTap((object sender, point e) => x = 0);

            CommandButton but1 = new CommandButton("Next >", 200, 200);
            frm.AddChild(but1);
            if (x <= 1)
            {
                but1.Tap += new OnTap((object sender, point e) => TestPage7(0, z +=
x));
            }
            else
                TestPage6(x, z);

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
        }
        private static void TestPage7(int x, int z)
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            //q7
            Label lab = new Label("7. A nail is hammered on the wall for hanging
clothes. After a few use the nail starts rotating. What solution cannot be
applied?", 4, 5, 300, 250);
            frm.AddChild(lab);
            RadioButton ans = new RadioButton(4, 60,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
            RadioButton ans2 = new RadioButton(4, 100,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 140,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
            RadioButton ans4 = new RadioButton(4, 180,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("The shape of the nail rod should be non
circular to avoid rotation.", 25, 60, 250, 50));
            frm.AddChild(new Label("The nail should be hammered until a hook shape
is achieved.", 25, 100, 250, 50));
            frm.AddChild(new Label("We can take a standard circular nail and hammer
it to flaten before fixing on the wall.", 25, 140, 250, 25));
            frm.AddChild(new Label("None of the above.", 25, 180, 250, 50));
```

```
            ans.Tap += new OnTap((object sender, point e) => x = 0);
            ans2.Tap += new OnTap((object sender, point e) => x = 1);
            ans3.Tap += new OnTap((object sender, point e) => x = 0);
            ans4.Tap += new OnTap((object sender, point e) => x = 0);

            CommandButton but1 = new CommandButton("Next >", 200, 200);
            frm.AddChild(but1);
            if (x <= 1)
            {
                but1.Tap += new OnTap((object sender, point e) => TestPage8(0, z +=
x));
            }
            else
                TestPage7(x, z);

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
        }
        private static void TestPage8(int x, int z)
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            //q8
            Label lab = new Label("8. A principle which states that, in order to
compensate for the weight of an object, merge it with other objects that provide
lift.", 4, 5, 300, 250);
            frm.AddChild(lab);
            RadioButton ans = new RadioButton(4, 60,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
            RadioButton ans2 = new RadioButton(4, 80,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 100,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
            RadioButton ans4 = new RadioButton(4, 120,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("Equipotentiality.", 25, 60, 250, 50));
            frm.AddChild(new Label("Parameter change.", 25, 80, 250, 50));
            frm.AddChild(new Label("Periodic Action.", 25, 100, 250, 25));
            frm.AddChild(new Label("None of the above.", 25, 120, 250, 50));
            ans.Tap += new OnTap((object sender, point e) => x = 0);
            ans2.Tap += new OnTap((object sender, point e) => x = 0);
            ans3.Tap += new OnTap((object sender, point e) => x = 0);
            ans4.Tap += new OnTap((object sender, point e) => x = 1);

            CommandButton but1 = new CommandButton("Next >", 200, 200);
            frm.AddChild(but1);
            if (x <= 1)
            {
```

```
                but1.Tap += new OnTap((object sender, point e) => TestPage9(0, z +=
x));
            }
            else
                TestPage8(x, z);

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
        }
        private static void TestPage9(int x, int z)
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            //q9
            Label lab = new Label("9. A principle which makes each part of an
object function in conditions most suitable for its operation.", 4, 5, 300, 250);
            frm.AddChild(lab);
            RadioButton ans = new RadioButton(4, 60,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
            RadioButton ans2 = new RadioButton(4, 80,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 100,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
            RadioButton ans4 = new RadioButton(4, 120,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("Local quality.", 25, 60, 250, 50));
            frm.AddChild(new Label("Other way around.", 25, 80, 250, 50));
            frm.AddChild(new Label("Extraction.", 25, 100, 250, 25));
            frm.AddChild(new Label("Segmentation.", 25, 120, 250, 50));
            ans.Tap += new OnTap((object sender, point e) => x = 1);
            ans2.Tap += new OnTap((object sender, point e) => x = 0);
            ans3.Tap += new OnTap((object sender, point e) => x = 0);
            ans4.Tap += new OnTap((object sender, point e) => x = 0);

            CommandButton but1 = new CommandButton("Next >", 200, 200);
            frm.AddChild(but1);
            if (x <= 1)
            {
                but1.Tap += new OnTap((object sender, point e) => TestPage10(0, z
+= x));
            }
            else
                TestPage9(x, z);

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
```

```
        }
        private static void TestPage10(int x, int z)
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;

            //q10
            Label lab = new Label("10. Error Messages can be an example of what
principle?", 4, 5, 300, 250);
            frm.AddChild(lab);
            RadioButton ans = new RadioButton(4, 40,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans);
            RadioButton ans2 = new RadioButton(4, 60,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans2);
            RadioButton ans3 = new RadioButton(4, 80,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans3);
            RadioButton ans4 = new RadioButton(4, 100,
Microsoft.SPOT.Presentation.Media.Color.White);
            frm.AddChild(ans4);
            frm.AddChild(new Label("Periodic action.", 25, 40, 250, 50));
            frm.AddChild(new Label("Preliminary action.", 25, 60, 250, 50));
            frm.AddChild(new Label("Preliminary anti-action.", 25, 80, 250, 25));
            frm.AddChild(new Label("Skipping.", 25, 100, 250, 50));
            ans.Tap += new OnTap((object sender, point e) => x = 0);
            ans2.Tap += new OnTap((object sender, point e) => x = 0);
            ans3.Tap += new OnTap((object sender, point e) => x = 1);
            ans4.Tap += new OnTap((object sender, point e) => x = 0);

            CommandButton but1 = new CommandButton("Next >", 200, 200);
            frm.AddChild(but1);
            if (x <= 1)
            {
                but1.Tap += new OnTap((object sender, point e) => EndPage(0, z +=
x));
            }
            else
                TestPage10(x, z);

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.FadeWhite);
        }

        private static void EndPage(int x, int z)
        {
            Form frm = new Form(Colors.White);
            frm.Font = Fonts.Verdana10;
            frm.AutoScroll = true;
            frm.AddChild(new Label("You have finished answering all the
questions!",4,20,300,100));
            CommandButton but = new CommandButton("View Results",5,40,95,25);
            frm.AddChild(but);
```

```
            but.Tap += new OnTap((object sender, point e) => Dialogs.Prompt("You've
scored " + z + " out of 10 questions","TRIZ Quiz", PromptType.OKOnly));
            CommandButton but1 = new CommandButton("Back to Main", 5, 80, 95, 25);
            frm.AddChild(but1);
            but1.Tap += new OnTap((object sender, point e) => gameStart1());

            // Set the return transition
            RetTrans = Transitions.FadeBlack;

            // Activate the form
            Graphics.ScreenTransition(frm, Transitions.SlideLeft);
        }
        #endregion
        #region Help Menu
        //*************************************about
TRIZ*************************************//
        static void AboutTrizScreen(int x)
        {
            //Create the form for About TRIZ
            Form formAbtTriz = new Form(Colors.Black);
            formAbtTriz.BackgroundImage =
Resources.GetBitmap(Resources.BitmapResources.TRIZ);
            if (x == 1)
            {
                //Activates the form with Crossfade effect
                Graphics.ScreenTransition(formAbtTriz, Transitions.FadeBlack);
            }
            else if (x == 2)
            {
                Graphics.ScreenTransition(formAbtTriz, Transitions.SlideRight);
            }
            //Buttons for forward and background shifting
            // Tap event for <
            //Add nuttons to the form
            //Returning transition
            CommandButton btnBack = new CommandButton("<", 372, 235, 22, 22);
            btnBack.Tap += new OnTap((object sender, point e) => ShowMainForm());
            CommandButton btnNxtAbtTriz = new CommandButton(">", 404, 235, 22, 22);
            btnNxtAbtTriz.Tap += new OnTap((object sender, point e) =>
AboutTrizScreen2());
            formAbtTriz.AddChild(btnBack);
            formAbtTriz.AddChild(btnNxtAbtTriz);
            RetTrans = Transitions.SlideRight;
        }
        private static void AboutTrizScreen2()
        {
            //Create the next page for this section
            Form formAbtTriz2 = new Form(Colors.Black);
            formAbtTriz2.BackgroundImage =
Resources.GetBitmap(Resources.BitmapResources.TRIZ2);
            Graphics.ScreenTransition(formAbtTriz2, Transitions.SlideLeft);

            //CommandButton(string text, Font font, Color ForeColor, int x, int y,
int width, int height)
            CommandButton btnBackAbtTriz = new CommandButton("<", 372, 235, 22,
22);
            btnBackAbtTriz.Tap += new OnTap((object sender, point e) =>
AboutTrizScreen(2));
```

```
            formAbtTriz2.AddChild(btnBackAbtTriz);
        }

        //*************************************about the
DEVICE**********************************//
        private static void AboutDvcScreen()
        {
            //Create the form about the Device
            //BG for the form
            //Transition using Fadeblack
            Form formDevice = new Form(Colors.Blue);
            formDevice.BackgroundImage =
Resources.GetBitmap(Resources.BitmapResources.DeviceInfo);
            Graphics.ScreenTransition(formDevice, Transitions.FadeBlack);

            //For arrow button
            //CommandButton(string text, Font font, Color ForeColor, int x, int y,
int width, int height)
            //Background image for button
            //Add button to the form
            CommandButton btnBackDevice = new CommandButton("<", 47, 232, 22, 22);
            //   btnBackDevice.Image =
Resources.GetBitmap(Resources.BitmapResources.BgforButton);
            btnBackDevice.Tap += new OnTap((object sender, point e) =>
ShowMainForm());
            formDevice.AddChild(btnBackDevice);
            RetTrans = Transitions.SlideRight;
        }

        //*************************************How to
Use*****************************************//
        private static void HowToScreen()
        {
            Form formHowTo = new Form(Colors.DarkGray);
            formHowTo.BackgroundImage =
Resources.GetBitmap(Resources.BitmapResources.HowToUse);
            Graphics.ScreenTransition(formHowTo, Transitions.FadeBlack);

            CommandButton btnBackHowTo = new CommandButton("<", 215, 240, 22, 22);
            btnBackHowTo.Tap += new OnTap((object sender, point e) =>
ShowMainForm());
            formHowTo.AddChild(btnBackHowTo);
            RetTrans = Transitions.SlideRight;
        }

        #endregion

        #region ShowMainForm
        private static void ShowMainForm()
        {
            //Clear active container
            Graphics.ActiveContainer.Suspended = true;
            Graphics.ActiveContainer.ClearChildren();
            Graphics.ActiveContainer = null;
            Debug.GC(true);

            //transition back to main form
            Graphics.ScreenTransition(formMain, RetTrans);
```

```
            Debug.GC(true);
        }
        #endregion


        #region Database

        public static void Initialize()
        {
            Connect();
            Prin();
            Param();
            PrinExample();
            PrinExplain();
            ParamToPrin();
            View();
        }

        public static void Connect()
        {
            try
            {
                connection = new SQLiteConnection("Data Source=:memory:");
                connection.Open();
            }
            catch (Exception ex)
            {
                Dialogs.Prompt(ex.ToString(), "Error Connection",
PromptType.OKOnly);
            }
        }

        public static void Param()
        {
            try
            {
                //database create table
                cmd = new SQLiteCommand("CREATE TABLE Param(ParamID INTEGER PRIMARY
KEY ASC, Param TEXT, ParamExplain TEXT)", connection);
                cmd.ExecuteNonQuery();

                //database input data
                for (i = 0; i < 40; i++)
                {
                    cmd.CommandText = "Insert into Param (Param, ParamExplain)
values ('" + para[i] + "', '" + paramexplain[i] + "')";
                    cmd.ExecuteNonQuery();
                }
            }
            catch (Exception ex)
            {
                Dialogs.Prompt("Connection Error", "Param", PromptType.OKOnly);
            }
        }

        public static void Prin()
        {
            try
```

```
            {
                //database create table
                cmd = new SQLiteCommand("CREATE TABLE Principle(PrinId INTEGER
PRIMARY KEY ASC, Prin TEXT, PrinExplain Integer ASC, Params TEXT)", connection);
                cmd.ExecuteNonQuery();

                //database input data
                for (i = 0; i < 41; i++)
                {
                    cmd.CommandText = "Insert into Principle (Prin, Params) values
('" + prin[i] + "','" + prinparams[i] + "' )";
                    cmd.ExecuteNonQuery();
                }
            }
            catch (Exception ex)
            {
                Dialogs.Prompt("Connection Error", "Prin", PromptType.OKOnly);
            }
        }

        public static void ParamToPrin()
        {
            try
            {
                //database create table
                cmd = new SQLiteCommand("CREATE TABLE ParamToPrin(Worse INTEGER
ASC, Improve INTEGER ASC, Prin1 Integer ASC, Prin2 Integer ASC, Prin3 Integer ASC,
Prin4 Integer ASC)", connection);
                cmd.ExecuteNonQuery();

                for (i = 1; i < 40; i++)
                {
                    cmd.CommandText = "Insert into ParamToPrin (Worse, Improve,
Prin1, Prin2, Prin3, Prin4) values ('" + i + "','" + i + "','" + i + "','" + i +
"','" + i + "','" + i + "' )";
                    cmd.ExecuteNonQuery();
                }
            }
            catch (Exception ex)
            {
                Dialogs.Prompt("Connection Error", "PTP", PromptType.OKOnly);
            }
        }

        public static void PrinExplain()
        {
            try
            {
                //database create table
                cmd = new SQLiteCommand("CREATE TABLE PrinExplain(PrinExpId INTEGER
PRIMARY KEY ASC, PrinExpA TEXT, PrinExpB TEXT, PrinExpC TEXT, PrinExpD TEXT,
PrinExpE TEXT)", connection);
                cmd.ExecuteNonQuery();

                //database input data
                for (i = 0; i < 41; i++)
                {
```

```
                    cmd.CommandText = "Insert into PrinExplain (PrinExpA, PrinExpB,
PrinExpC, PrinExpD, PrinExpE) values ('" + prinExplainA[i] + "','" +
prinExplainB[i] + "','" + prinExplainC[i] + "','" + prinExplainD[i] + "','" +
prinExplainE[i] + "' )";
                    cmd.ExecuteNonQuery();
                }
            }

            catch (Exception ex)
            {
                Dialogs.Prompt("Connection Error", "PrinExp", PromptType.OKOnly);
            }
        }

        public static void PrinExample()
        {
            try
            {
                //database create table
                cmd = new SQLiteCommand("CREATE TABLE PrinExample(PrinExaId INTEGER
PRIMARY KEY ASC, PrinExaA TEXT, PrinExaB TEXT, PrinExaC TEXT, PrinExaD TEXT,
PrinExaE TEXT)", connection);
                cmd.ExecuteNonQuery();

                //database input data
                for (i = 0; i < 41; i++)
                {
                    cmd.CommandText = "Insert into PrinExample (PrinExaA, PrinExaB,
PrinExaC, PrinExaD, PrinExaE) values ('" + prinExampleA[i] + "','" +
prinExampleB[i] + "','" + prinExampleC[i] + "','" + prinExampleD[i] + "','" +
prinExampleE[i] + "' )";
                    cmd.ExecuteNonQuery();
                }
            }
            catch (Exception ex)
            {
                Dialogs.Prompt("Connection Error", "PrinExa", PromptType.OKOnly);
            }
        }

        public static void View()
        {
            try
            {
                 cmd = new SQLiteCommand("CREATE VIEW View AS " +
                 "SELECT Improve.Param AS Improve, Improve.ParamExplain AS
ImproveExp, Worse.Param AS Worse, Worse.ParamExplain AS WorseExplain," +
                "Prin1.Prin AS Prin1, Prin2.Prin AS Prin2, Prin3.Prin AS Prin3,
Prin4.Prin AS Prin4, " +
                      "Prin1.Params AS Pair1, Prin2.Params AS Pair2, Prin3.Params
AS Pair3, Prin4.Params AS Pair4, " +
                "Exp1.PrinExpA AS Prin1Exp1, Exp2.PrinExpA AS Prin2Exp1,
Exp3.PrinExpA AS Prin3Exp1, Exp4.PrinExpA AS Prin4Exp1, " +
                "Exp1.PrinExpB AS Prin1Exp2, Exp2.PrinExpB AS Prin2Exp2,
Exp3.PrinExpB AS Prin3Exp2, Exp4.PrinExpB AS Prin4Exp2, " +
                "Exp1.PrinExpC AS Prin1Exp3, Exp2.PrinExpC AS Prin2Exp3,
Exp3.PrinExpC AS Prin3Exp3, Exp4.PrinExpC AS Prin4Exp3, " +
```

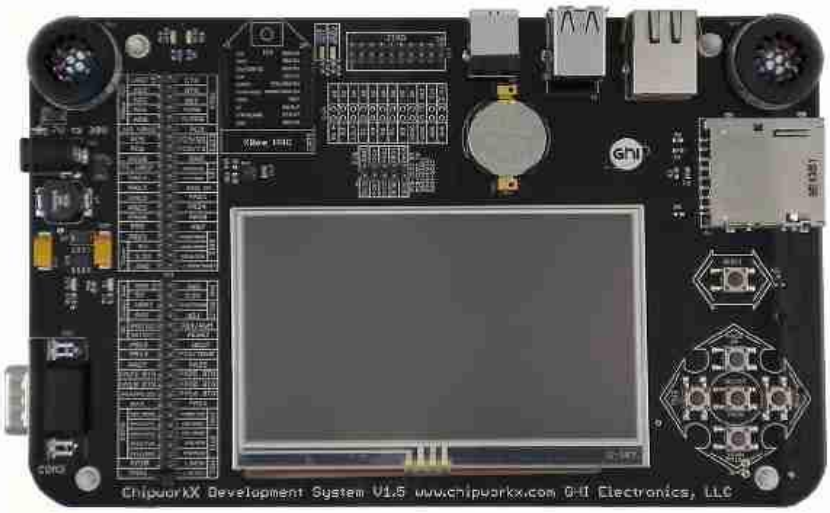
```
                "Exp1.PrinExpD AS Prin1Exp4, Exp2.PrinExpD AS Prin2Exp4,
Exp3.PrinExpD AS Prin3Exp4, Exp4.PrinExpD AS Prin4Exp4, " +
                "Exp1.PrinExpE AS Prin1Exp5, Exp2.PrinExpE AS Prin2Exp5,
Exp3.PrinExpE AS Prin3Exp5, Exp4.PrinExpE AS Prin4Exp5, " +
                "Exa1.PrinExaA AS Prin1Exa1, Exa2.PrinExaA AS Prin2Exa1,
Exa3.PrinExaA AS Prin3Exa1, Exa4.PrinExaA AS Prin4Exa1, " +
                "Exa1.PrinExaB AS Prin1Exa2, Exa2.PrinExaB AS Prin2Exa2,
Exa3.PrinExaB AS Prin3Exa2, Exa4.PrinExaB AS Prin4Exa2, " +
                "Exa1.PrinExaC AS Prin1Exa3, Exa2.PrinExaC AS Prin2Exa3,
Exa3.PrinExaC AS Prin3Exa3, Exa4.PrinExaC AS Prin4Exa3, " +
                "Exa1.PrinExaD AS Prin1Exa4, Exa2.PrinExaD AS Prin2Exa4,
Exa3.PrinExaD AS Prin3Exa4, Exa4.PrinExaD AS Prin4Exa4, " +
                "Exa1.PrinExaE AS Prin1Exa5, Exa2.PrinExaE AS Prin2Exa5,
Exa3.PrinExaE AS Prin3Exa5, Exa4.PrinExaE AS Prin4Exa4, " +
                "Prin1.PrinID AS PrinID "+
                "FROM ParamToPrin AS PTP "+
                "INNER JOIN Param AS Worse ON Worse.ParamID = PTP.Worse "+
                "INNER JOIN Param AS Improve ON Improve.ParamID = PTP.Improve " +
                "INNER JOIN Principle AS Prin1 ON Prin1.PrinID = PTP.Prin1 " +
                "INNER JOIN Principle AS Prin2 ON Prin2.PrinID = PTP.Prin2 " +
                "INNER JOIN Principle AS Prin3 ON Prin3.PrinID = PTP.Prin3 " +
                "INNER JOIN Principle AS Prin4 ON Prin4.PrinID = PTP.Prin4 " +
                "INNER JOIN PrinExplain AS Exp1 ON Exp1.PrinExpID = Prin1.PrinID "
+
                "INNER JOIN PrinExplain AS Exp2 ON Exp2.PrinExpID = Prin2.PrinID "
+
                "INNER JOIN PrinExplain AS Exp3 ON Exp3.PrinExpID = Prin3.PrinID "
+
                "INNER JOIN PrinExplain AS Exp4 ON Exp4.PrinExpID = Prin4.PrinID "
+
                "INNER JOIN PrinExample AS Exa1 ON Exa1.PrinExaID = Exp1.PrinExpID
" +
                "INNER JOIN PrinExample AS Exa2 ON Exa2.PrinExaID = Exp2.PrinExpID
" +
                "INNER JOIN PrinExample AS Exa3 ON Exa3.PrinExaID = Exp3.PrinExpID
" +
                "INNER JOIN PrinExample AS Exa4 ON Exa4.PrinExaID = Exp4.PrinExpID
", connection);
                 cmd.ExecuteNonQuery();
            }
            catch (Exception ex)
            {
                Dialogs.Prompt("Connection Error", "View", PromptType.OKOnly);
            }
        }

        #endregion
    }
}
```

APPENDIX C

Data Sheets

ChipworkX™ Development System



ChipworkX™ Development System is the official kit from GHI Electronics for the ChipworkX™ module. ChipworkX™ offers high performance and provides extensive capabilities. This kit exposes the various peripherals and interfaces that make it an ideal starting point for any .NET Micro Framework project. Furthermore, most of ChipworkX™ module signals such as GPIO, SPI and UART are accessible on a 0.1" header for rapid prototyping.

What is .NET Micro Framework?

Microsoft's .NET Micro Framework extends the advantages of .NET and Visual Studio to a class of smaller, less expensive, and more resource-constrained devices than the .NET Compact Framework or the standard .NET framework.

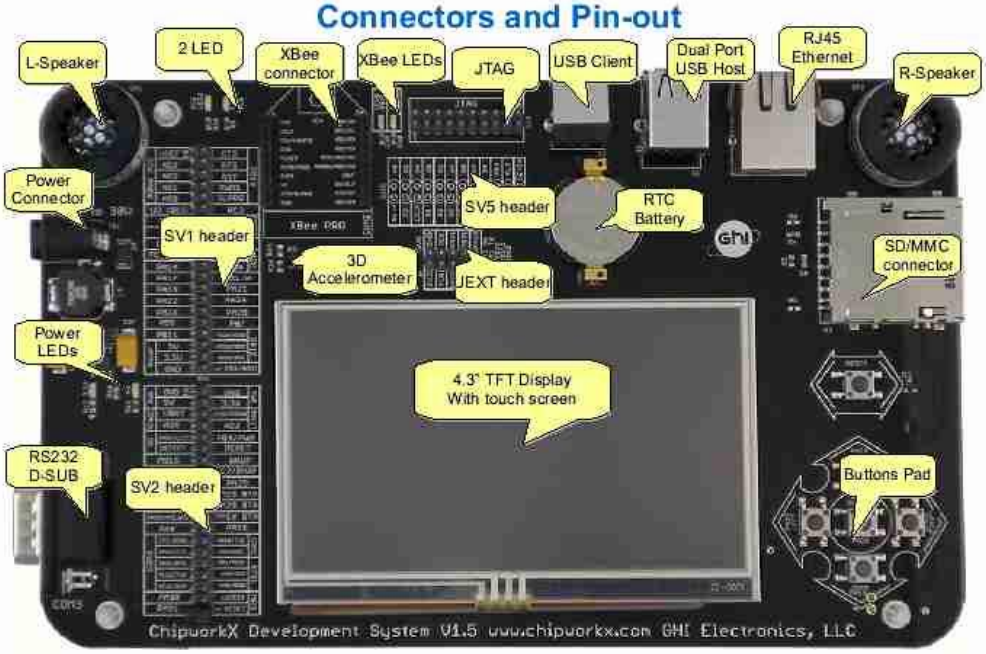
What is ChipworkX Module?

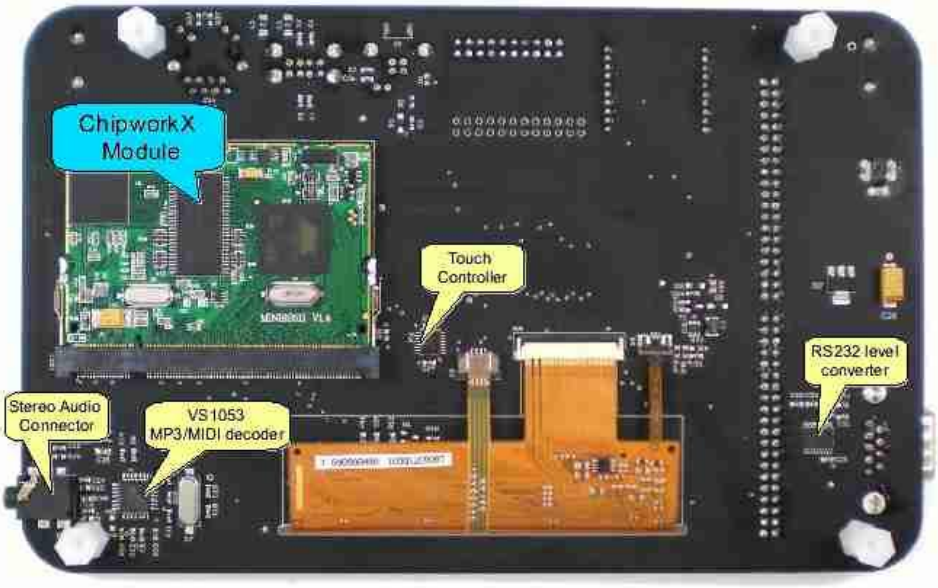
ChipworkX™ implements Microsoft .NET Micro Framework on a small (67.6mm x47mm) OEM board with SO-DIMM200 slot running very high performance ARM9 processor. On top of the many benefits that .NET Micro Framework has, ChipworkX™ adds many other exclusive software and hardware features such as USB host, SQLite database, and Runtime Loadable Procedure (allowing advanced users to run compiled C/assembly right in C# code). ChipworkX™ supports WiFi through ZeroG ZG2100 modules. Refer to the ChipworkX™ Module brochure for full features.

Key Features

- ChipworkX™ Module with .NET Micro Framework:
  - 200 MHz 32-bit ARM 9 Processor
  - 64MB RAM and 8MB FLASH
  - 256MB Internal Flash with File System.
- 480x272 4.3" TFT Display with touch screen.
- GHI NETMF WiFi Expansion compatible.
- RJ-45 Ethernet connector
- Standard JTAG connector
- TFT signals exposed
- GPIO signals with interrupts exposed on 0.1" header pins
- 2 SPI (8/16bit)
- I2C
- 3 UART (serial ports), one RS232 interface with hardware handshaking.
- 1 PWM
- One-wire interface support
- SD/MMC card connector with spring.
- USB Device port
- Dual USB Host ports
- XBee module connector
- 3D-axis Accelerometer chip BMA020
- MP3\MIDI decoder chip VS1053
- UEXT interface for easy expansions from Olimex such as GPS and RFID Reader.
- Touch screen controller with 2 ADC ports
- Real Time Clock backup battery.
- LEDs and push buttons
- Can be power through USB or 7~30 volt DC power.
- DC power input 7~ 30 volts
- RoHS Lead Free

Connectors and Pin-out





SV1

XBee ADC	VREF	40	39	CTS	XBee
	AD3	38	37	RTS	
	AD2	36	35	RST	
	AD1	34	33	PWM1	
	AD0	32	31	SLPRQ	
UD VBUS		30	29	PC3	
PC5		28	27	PC9/RX	COM2
PC6		26	25	PC8/TX	
PC10		24	23	PA5	
PA6/SDCard_CS		22	21	PA8/CLK	I2C
PA14		20	19	PA7/SDA	
PA17		18	17	Accelerometer Interrupt	
PA19		16	15	PA21	
PA22		14	13	PA24	
PA26		12	11	PA28	
PB5		10	9	PB7	
PB21		8	7	PB30/MISO	SPI2
Power	5Volts	6	5	PB31/MOSI	
	3.3Volts	4	3	PB29/SCK	
	Ground	2	1	PB3/BOOT	

SV2

PWR	Ground	40	39	Ground	PWR
	5Volts	38	37	3.3Volts	
Touch Controller ADC	VBAT	36	35	shutdown	Back Light
	AUX	34	33	ADJ	
SD	Protect	32	31	PB4/PWM	
	Detect	30	29	RESET	
PB15		28	27	Wake Up	
PB13		26	25	PC2/IRQ0	
PA27		24	23	PA29	
PA23		22	21	PA25	
PA18		20	19	PA20	
PA15/MP3_DCS		18	17	PA16	
PA4		16	15	PA11	
COM3	RS232 Disable	14	13	PA10/TXD	COM1
	PA13/CTS	12	11	PA9/RXD	
	PA12/RTS	10	9	PA1/MOSI	
	PC12/TXD	8	7	PA2/SCK	SPI1
	PC13/RXD	6	5	PA0/MISO	
PA30		4	3	Line In	MP3
PA31		2	1	Reset	

SV5

Red0	Red2	Red4	Green0	Green2	Green4	Blue0	Blue2	Blue4	PB3	CLK	5Volts
2	4	6	8	10	12	14	16	18	20	22	24
1	3	5	7	9	11	13	15	17	19	21	23
Red1	Red3	LCD Clock	Green1	Green3	Green5	Blue1	Blue3	H-Sync	V-Sync	SDA	Ground

SV6 (on hardware version 1.5)

3.3 Volts (Out)	1	2	Ground
PC8/COM2_TX	3	4	PC9/COM2_RX
PA22	5	6	PA21
PB30/SPI2_MISO	7	8	PB31/SPI2_MOSI
PB29/SPI2_SCK	9	10	PA19

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LEDs

LED name	LED1	LED2	LED6	LED7	3.3V	5V
Connection	PC6	PC5	XBee RSSI	XBee ASSOC	3.3 Volt supply	5 volt supply

Push Buttons

Button name	UP	DOWN	LEFT	RIGHT	SELECT	RESET
Connection	PA23	PA18	PA25	PA16	PA20	System Hard Reset

TFT Display Back Light control: By default, back light is set to maximum illumination and it can be adjusted through PWM signal by closing a jumper between pin SV2-31(PB4/PWM) and pin SV2-33 (ADJ).

Touch Screen Controller with ADC: TSC2046 touch controller chip with 2 analog inputs is used to access touch screen. It is controlled though SPI1. User can utilize the two analog inputs of TSC2046 (VBAT and AUX) as Analog to Digital converters which are exposed on SV2 header. More analog inputs are also available when adding XBee module.

ChipworkX™ Development System Kit Includes:

- ChipworkX™ Development System Main Board.
- ChipworkX™ Module.
- 4.3" TFT Display with Touch Screen.
- RTC Battery.
- USB Cable.

Important Note1: WiFi-Expansion is not included with the kit.

WiFi RS21 Module with UEXT Connector

Important Note2: XBee module is not included with the kit.

XBee modules are available from Digi:

http://www.digi.com/products/embeddedsolutions/zigbeesolutions/

For more information:

Related Document

ChipworkX™ Module Brochure and Pin out

ChipworkX™ User Manual

Weblinks

MP3/Mini Decoder chip:

http://www.vlsi.fi/en/products/vs1053.html

Customer Technical Support

http://www.ghielectronics.com/support

ghi electronics
51410 Milano Dr. Suite 114
Macomb Township, MI 48042
United States
PH: +1 586 693 2696
FAX: +1 586 693 3449
www.ghielectronics.com

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PRODUCT SPECIFICATIONS

SHARP

AVC Liquid Crystal Displays Group

LK043T1DG01

TFT-LCD Module

Spec. Issue Date: July, 21 2006

No: LCY-W-06602A

PREPARED BY: DATE	SHARP	SPEC No. LCY-W-06602A
		FILE No.
APPROVED BY: DATE	MOBILE LIQUID CRYSTAL DISPLAY GROUP SHARP CORPORATION	ISSUE Jul.21.2006
		PAGE Pages 24
		APPLICABLE DIVISION MOBILE LCD CHINA DESIGN CENTER WUXI SHARP
	SPECIFICATION	

DEVICE SPECIFICATION for

TFT LCD Module

(480 × RGB × 272 dots)

Model No.

LQ043T1DG01

☐CUSTOMER'S APPROVAL

DATE _____

BY _____

PRESENTED BY K. Yamamoto

YAMAMOTO.KUNIHIKO

GENERAL MANAGER
MOBILE LCD CHINA DESIGN CENTER
WUXI SHARP

SHARP

RECORDS OF REVISION				DOC. First issue	Jun. 30. 2006
				Model No.	LQ043T1DG01
				Spec. No.	LCY-W-06602A
DATE	REF.PAGE PARAGRAPH DRAWING No.	REVISED NO.	SUMMARY		CHECK AND APPROVAL
Jun. 30. 2006			First Issue		K. Yamamoto
Jul. 21. 2006	Page 9, 11	1	Addition of AC timing (Clock vs. V/Hsync)		K. Yamamoto
Jul. 21. 2006	Page 22	1	Change in thickness tolerance (0.30→0.25)		K. Yamamoto

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·Test and measurement equipment ·Industrial control ·Personal digital assistant
·Audio visual and multimedia equipment ·Consumer electronics

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·Traffic signals ·Gas leakage sensor breakers
·Alarm equipment ·Various safety devices etc.

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1. Applicable Scope

This specification is applicable to TFT-LCD Module "LQ043T1DG01".

2. General Description

This module is a color active matrix LCD module incorporating amorphous silicon TFT (Thin Film Transistor). It is composed of a color TFT-LCD panel, driver ICs, Input FPC, a back light unit and a touch panel. Graphics and texts can be displayed on a 480×3×272 dots panel with about 16million colors by supplying 24bit data signals(8bit×RGB), Four timing signals, logic (typ. +3.3V), analog (typ. +5V) supply voltages for TFT-LCD panel driving and supply voltage for back light.

3. Mechanical (Physical) Specifications

Item	Specifications	Unit
Screen size	10.9 (4.3" type) diagonal	cm
Active area	95.04(H)×53.856(V)	mm
Pixel format	480(H)×272(V)	pixel
	1 Pixel =R+G+B dots	-
Pixel pitch	0.198(H)×0.198(V)	mm
Pixel configuration	R,G,B vertical stripes	-
Display mode	Normally white	-
Unit outline dimensions	105.5(W)×67.2(H)×5.05(D)	mm
Mass	Approx. 62	g
Surface treatment	Anti-glare, 2H	-

□ The above-mentioned table indicates module sizes without some projections and FPC. For detailed measurements and tolerances, please refer to Fig.1.

4. Input Terminal Names and Functions

4-1. TFT LCD Panel Driving (Reference Connector: Hirose Electric CO., LTD. Product No.: FH12A-40S-0.5SH (55) Top contact type)

□ The Bottom contact type can be selected according to side of mounted connector and terminal side of FPC.

Terminal No.	Terminal name	Function	Remarks
1	GND	GND(0V)	
2	GND	GND(0V)	
3	VCC	+3.3V power source	
4	VCC	+3.3V power source	
5	R0	RED Data Signal (LSB)	
6	R1	RED Data Signal	
7	R2	RED Data Signal	
8	R3	RED Data Signal	
9	R4	RED Data Signal	
10	R5	RED Data Signal	
11	R6	RED Data Signal	
12	R7	RED Data Signal (MSB)	
13	G0	GREEN Data Signal (LSB)	
14	G1	GREEN Data Signal	
15	G2	GREEN Data Signal	
16	G3	GREEN Data Signal	
17	G4	GREEN Data Signal	
18	G5	GREEN Data Signal	
19	G6	GREEN Data Signal	
20	G7	GREEN Data Signal (MSB)	
21	B0	BLUE Data Signal (LSB)	
22	B1	BLUE Data Signal	
23	B2	BLUE Data Signal	
24	B3	BLUE Data Signal	
25	B4	BLUE Data Signal	
26	B5	BLUE Data Signal	
27	B6	BLUE Data Signal	
28	B7	BLUE Data Signal (MSB)	
29	GND	GND(0V)	
30	CK	Clock signal to sample each date	
31	DISP	Display ON/OFF Signal	
32	Hsync	Horizontal synchronizing signal	
33	Vsync	Vertical synchronizing signal	
34	NC	NC	Note 1
35	AVDD	+5V Analog power source	
36	AVDD	+5V Analog power source	
37	NC	NC	Note 1
38	TEST1	TEST1	Note 2
39	TEST2	TEST2	Note 3
40	TEST3	TEST3	Note 3

Note 1) They have been open within FPC.

Note 2) Please be sure to set 38 pins (TEST1) to open.

Note 3) Please be sure to connect 39 pin (TEST2), 40 pin (TEST3) with GND.

4-2. Backlight

0.5mmP 4Pin FPC (Reference Connector: Kyocera Elco Corporation Product No.: 6298 Bottom contact type)

□ The Bottom contact type can be selected according to side of mounted connector and terminal side of FPC.

Terminal No.	Signal	Function
1	V_{LED-}	LED Power Source Input terminal (Cathode side)
2	NC	No Connection
3	NC	No Connection
4	V_{LED+}	LED Power Source Input terminal (Anode side)

4-3.Touch panel

1mmP 4Pin FPC (Reference Connector: J.S.T. Mfg Co., Ltd, Product No.: 0.4(1.0)9FLH-SM1-GB-TB)

Terminal No.	Terminal name	Description
T1	YU	Y (12 o'clock side)
T2	XL	X (left side)
T3	YD	Y (6 o'clock side)
T4	XR	X (right side)

5. Absolute Maximum Ratings

Item	Symbol	Conditions	Rated value	Unit	Remarks
Input voltage	V_I	Ta=25°C	-0.3 ～ VCC+0.3	V	【Note 1】
3.3 V Power supply voltage	VCC	Ta=25°C	0 ～ +4.5	V	
5 V Power supply voltage	AVDD	Ta=25°C	0 ～ +6.0	V	
Temperature for storage	T_{stg}	-	-30 ～ +85	°C	【Note 2】
Temperature for operation	T_{opr}	-	-10 ～ +70	°C	【Note 3】
LED Input electric current	ILED	Ta=25°C	35	mA	【Note 4】
LED electricity consumption	PLED	Ta=25°C	123	mW	【Note 4】

【Note 1】 CK,R0～R7,G0～G7,B0～B7,Hsync,Vsync,DISP

【Note 2】 Humidity : 80%RHMax. (Ta≤40°C)

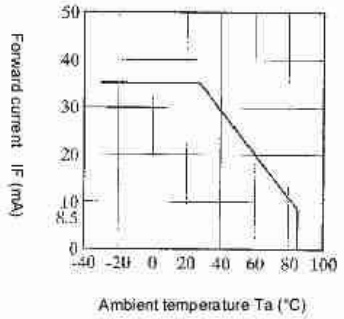
Maximum bulb temperature under 39°C (Ta>40°C) See to it that no dew will be condensed.

【Note 3】 Panel surface temperature prescribes.

(Reliability is examined at ambient temperature of 50°C.)

【Note 4】 Power consumption of one LED (Ta=25°C) (use 9 pieces LED)

Ambient temperature and the maximum input are fulfilling the following operating conditions.



Ambient temperature and the maximum input

6. Electrical Characteristics

6-1. TFT LCD Panel Driving

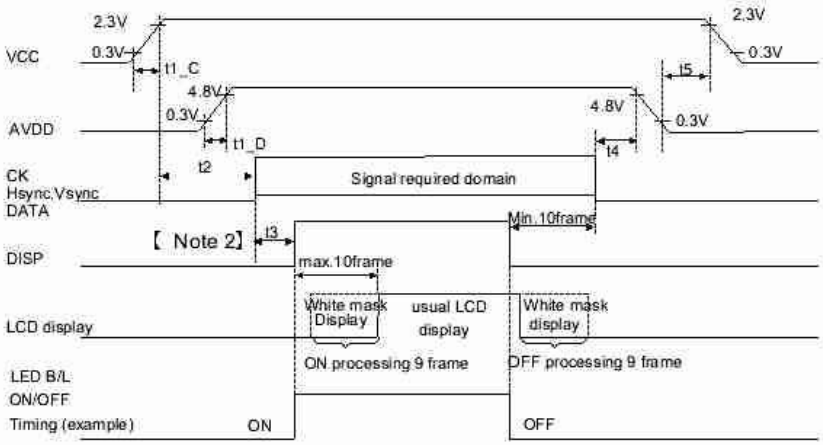
Ta = 25°C

Item		Symbol	Min.	Typ.	Max.	Unit	Remarks
+3.3V power supply	DC voltage	VCC	+2.3	+3.3	+3.6	V	【Note 1】
	DC current	Icc	-	0.5	2	mA	【Note 3】
+5V power supply	DC voltage	AVDD	+4.8	+5.0	+5.2	V	【Note 1】
	DC current	I_{AVDD}	-	8	16	mA	【Note 3】
Permissive input ripple voltage		V_{RFVCC}	-	-	100	mVp-p	VCC=+3.3V
		V_{RFAVDD}	-	-	100	mVp-p	AVDD=+5.0V
Input voltage (Low)		V_{IL}	-	-	0.2 V_{CC}	V	【Note 4】
Input voltage (High)		V_{IH}	0.8 V_{CC}	-	-	V	
Input current (Low)		I_{OL}	-	-	4.0	μA	V_I =0V 【Note 4】
Input current (High)		I_{OH}	-	-	4.0	μA	V_I =2.5V 【Note 4】

□ The rush current will flows when power supply is turned on, so please design the power supply circuit referring to 【Note 5】.
(The rush current changes according to the condition of the supply voltage value, rising time and so on.)

【 Note 1】

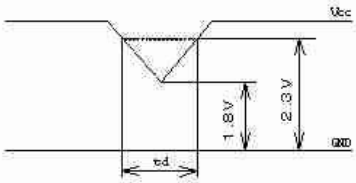
Sequences of supply voltage and signals



- Please do not supply AVDD before VCC.
- It discharges and boost up voltage for TFT module on the basis of a DISP-signal
  It drives Max-10 flames (about 0.2seconds) from change of DISP-signals by reasons that
  It takes time for 9 flames while each processing operation.
  Therefore, the display start is delayed for 10 flames and Ten or more frames needs to be
  voltage maintained at the time of a display end.
- It is not problem to set up DISP=L ,AVDD=GND when VCC voltage is supplied
- Please don't set various signals to Hi-Z when VCC-voltage is supplied
  in reason that those signals are CMOS input.
- Don't change DISP signal into the state of H level When AVDD voltage is in the state of GND.
- The ON/OFF timing of LED Back Light is an example.

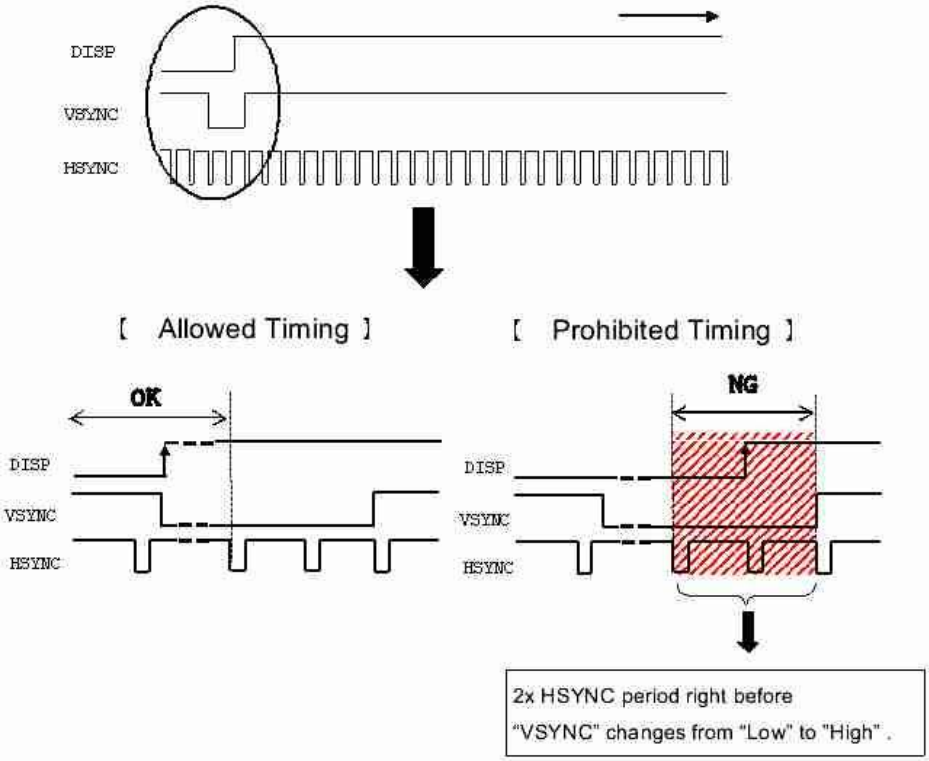
	MIN	TYP	MAX	unit	Remarks
t1_C	0	-	10	ms	
t1_D	0.5	-	10	ms	
t 2	50	-	-	ms	
t 3	0.5	-	-	ms	【 Note 2】
t 4	0	-	-	ms	
t 5	0	-	-	ms	

Dip Conditions for supply voltage

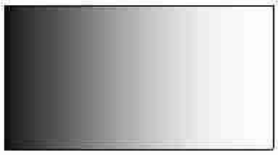


td□ 10ms

【 Note 2】 While "VSYNC" is "Low", don't change "DISP" signal "Low" to "High".



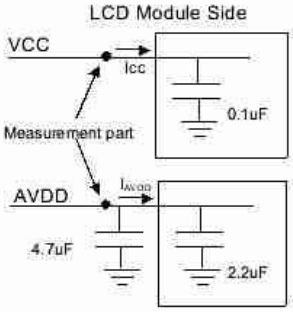
【 Note 3】 Typical current situation: 256-gray-bar pattern VCC=3.3V AVDD=5.0V



【 Note 4】 CK, R0～R7, G0～G7,B0～B7,Hsync,Vsync,DISP

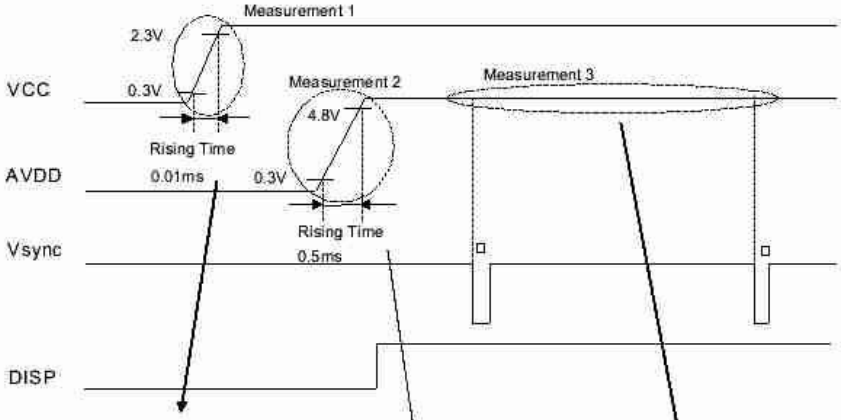
【 Note 5 】

An example of rush current measurement



□ Measurement conditions

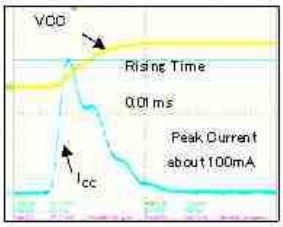
- Power supply voltage VCC : 3.3V AVDD : 5.0V
- Disp signal : OFF □ ON
- Other input signals : GND
- Measurement system : refer to right Fig.
- rush current measurement timing : refer to following Fig.



□ Measurement Example

Measurement 1
Y: 20mA/Div., 2V/Div., X: 0.003ms/Div.

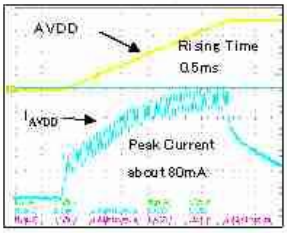
Icc

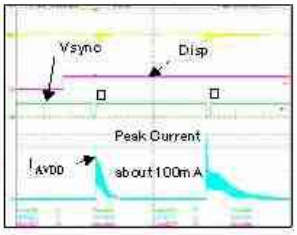


Measurement 2
Y: 20mA/Div., 2V/Div., X: 0.08ms/Div.

Measurement 3
Y: 50mA/Div., 5V/Div., X: 4ms/Div.

IAVDD





These rush current won't flow stationary,
these will flow at the timing shown in Measurement 3.

6-2. Back light driving

The back light system has nine LEDs

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remark
Rated Voltage	V_{BL}	-	28.8	31.5	V	
Rated Current	I_L	-	20	-	mA	Ta=25°C

7. Timing characteristics of input signals

An input signal timing waveform is shown in Fig. 2.

7-1 Timing characteristics

Parameter		Symbol	Min.	Typ.	Max.	Unit	Remark
Clock	Frequency	1/Tc	7.83	9.00	9.26	MHz	
	Duty ratio	Th/T	40	50	60	%	
	Cycle (1)	t_{CLK}	108	111	128	ns	
	High Width (1)	t_{CHW}	43	-	-	ns	
	Low Width (1)	t_{CLW}	43	-	-	ns	
(1) Vsync Setup Time		t_{VS}	25	-	-	ns	
(1) Hsync Setup Time		t_{HS}	25	-	-	ns	
DATA	Setup Time	t_{DS}	25	-	-	ns	
	Hold Time	t_{DH}	25	-	-	ns	
(1) Rising/Falling Time		t_{RF}	-	-	20	ns	
Horizontal synchronizing	Period	TH	-	525	-	Clock	
	Pulse width	THp	-	41	-	Clock	
	Horizontal period	THd	-	480	-	Clock	
	Back porch	THb	-	2	-	Clock	
	Front porch	THf	-	2	-	Clock	
Vertical synchronizing	Period	TV	-	286	-	Line	
	Pulse width	TVp	-	10	-	Line	
	Vertical period	TVd	-	272	-	Line	
	Back porch	TVb	-	2	-	Line	
	Front porch	TVf	-	2	-	Line	

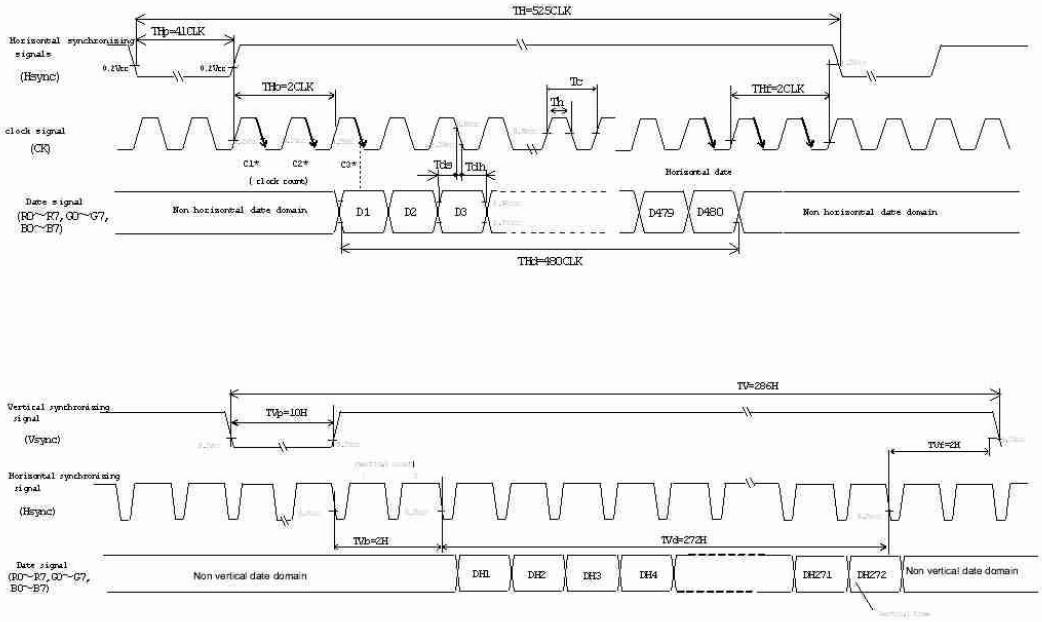
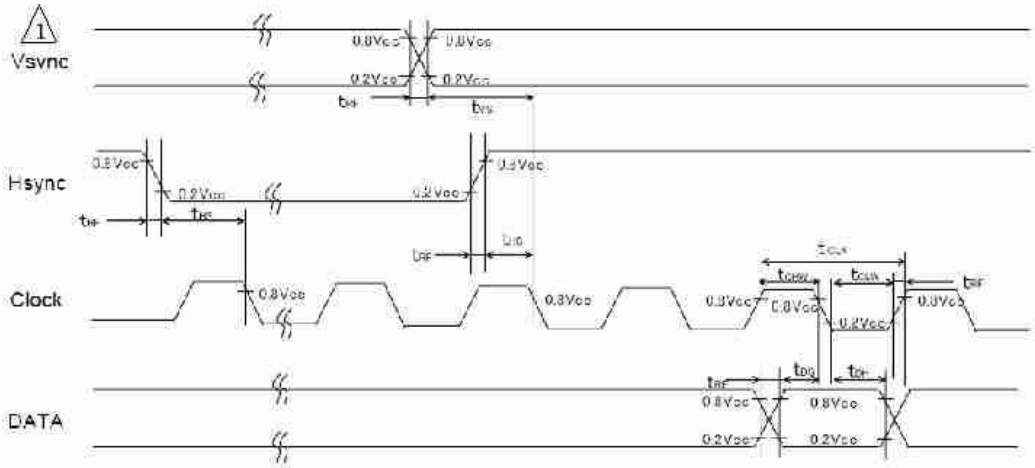
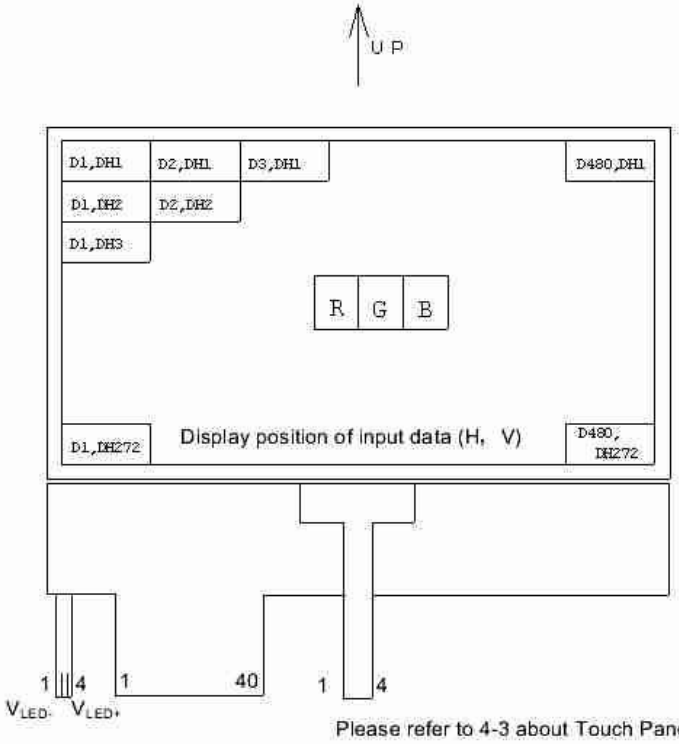


Fig.2 Input signal timing



【 Note】 · In case of using the slow frequency, the deterioration of display, flicker etc may occur.
· The timing characteristics are basically fixed as above.

7-3 Input Data Signals and Display Position on the screen



Please refer to 4-3 about Touch Panel Pin arrangement.

Please refer to 4-1 about Pin arrangement.

Please refer to 4-2 about LED side Pin arrangement.

8. Input Signals, Basic Display Colors and Gray Scale of Each Color

	Colors & Gray Scale	Gray Scale	Date signal																							
			R0	R1	R2	R3	R4	R5	R6	R7	G0	G1	G2	G3	G4	G5	G6	G7	B0	B1	B2	B3	B4	B5	B6	B7
			LSB							MSB	LSB							MSB	LSB							MSB
Basic Color	Black	–	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Blue	–	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	Green	–	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	Cyan	–	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Red	–	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Magenta	–	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	Yellow	–	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	White	–	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gray Scale of Red	Black	GS0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Darker	GS1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		GS2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Brighter	GS253	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		GS254	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Red	GS255	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gray Scale of Green	Black	GS0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Darker	GS1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		GS2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Brighter	GS253	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0
		GS254	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	Green	GS255	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Gray Scale of Blue	Black	GS0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Darker	GS1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		GS2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Brighter	GS253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1
		GS254	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
	Blue	GS255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

0: Low level voltage, 1: High level voltage

Each basic color can be displayed in 256 gray scales from 8 bit data signals. According to the combination of 24 bit data signals, the 16-million-color display can be achieved on the screen.

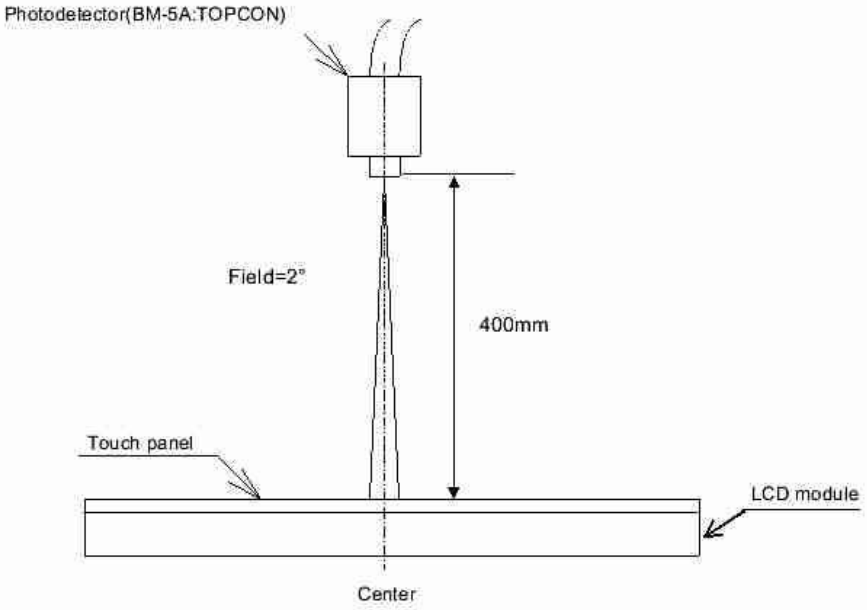
9. Optical Characteristics

Module characteristics

Ta = 25°C, VCC = +3.3V, AVDD = 5.0V

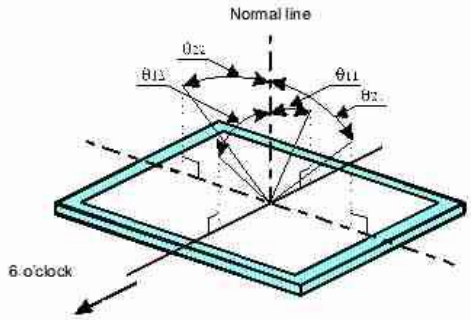
Parameter		Symbol	Condition	Min.	Typ.	Max.	Unit	Remark
Viewing angle range	Horizontal	θ21,θ22	CR>10	-	60	-	Deg.	【Note1,4】
	Vertical	θ11		-	40	-	Deg.	
		θ12		-	60	-	Deg.	
Contrast ratio		CR	Optimum viewing angle	100	300	-	-	【Note2,4】
Response Time	Rise	τ r	θ=0°	-	30	45	ms	【Note3,4】
	Decay	τ d		-	30	45	ms	
Chromaticity of White		x	θ=0°	0.26	0.31	0.36	-	【Note4】
		y		0.29	0.34	0.39	-	
Luminance of white		X_{L1}	θ=0°	400	500	-	cd/m²	I_{LED}=20mA 【Note4】
Uniformity		U	θ=0°	70	80	-	%	【Note5】

□ The optical characteristics measurements are operated under a stable luminescence(I_{LED}=20mA) and a dark condition. (Refer to following figure)



Measuring method (c) for optical characteristics

【 Note 1 】 Definitions of viewing angle range



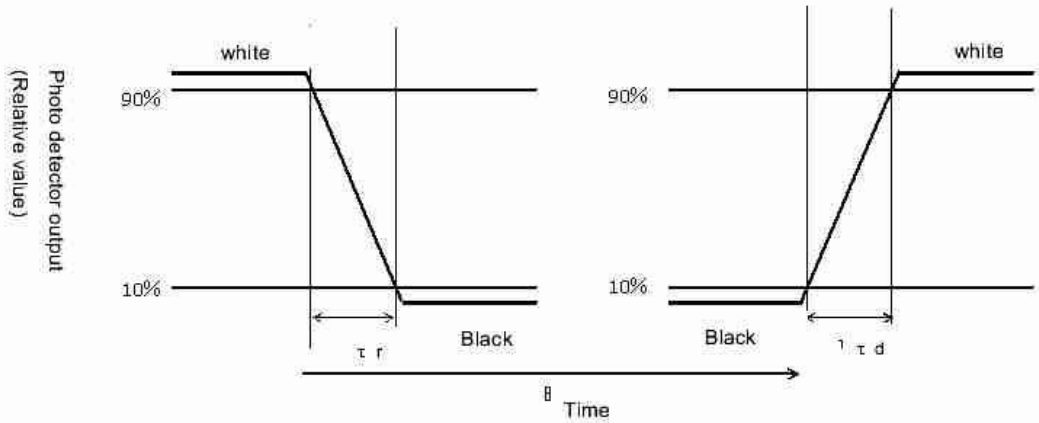
【 Note 2 】 Definition of contrast ratio

The contrast ratio is defined as the following

$$\text{Contrast ratio (CR)} = \frac{\text{Luminance (brightness) with all pixels white}}{\text{Luminance (brightness) with all pixels black}}$$

【 Note 3 】 Definition of response time

The response time is defined as the following figure and shall be measured by switching the input signal for "black" and "white"

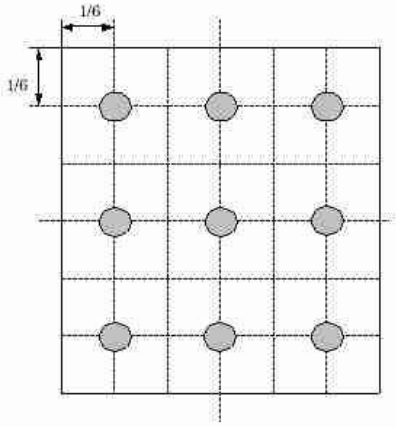


【 Note 4 】 This shall be measured at center of the screen.

【 Note 5 】 Definition of Uniformity.

$$\text{Uniformity} = \frac{\text{Minimum Brightness}}{\text{Maximum Brightness}} \times 100\,(\%)$$

The brightness should be measured on the 9-point as shown in the following figure.



10. Touch panel characteristics

Parameter	Min.	Typ.	Max.	Unit	Remark
Input voltage	-	5.0	7.0	V	
Resistor between terminals (XL-XR)	200	463	900	Ω	Provisional
Resistor between terminals (YU-YD)	160	291	640	Ω	specification
Line linearity (X direction)	-	-	1.5	%	
Line linearity (Y direction)	-	-	1.5	%	
Insulation resistance	20	-	-	MΩ	at DC25V
Minimum tension for detecting	-	-	0.88	N	

11. Mechanical characteristics

11-1) FPC (for LCD panel) characteristics

(1) Specific connector: FH12A-40S-0.5SH(55) (HIROSE)

(2) Bending endurance of the bending slits portion

No line of the FPC is broken for the bending test (Bending radius=0.6mm and angle=90°) in 30 cycles.

11-2) Design guidance for touch panel (T/P)

11-2-1) Example of housing design

(1) If a consumer will put a palm on housing in normal usage, care should be taken as follows.

(2) Keep the gap, for example 0.3 to 0.7mm, between bezel edge and T/P surface.

The reason is to avoid the bezel edge from contacting T/P surface that may cause a "short" with bottom layer (See Fig.3)

(3) Insertion a cushion material is recommended.

(4) The cushion material should be limited just on the busbar insulation paste area.

If it is over the transparent insulation paste area, a "short" may be occurred.

(5) There is one where a resistance film is left in the T/P part of the end of the pole.

Design to keep insulation from the perimeter to prevent from mis-operation and so on.

11-2-2) Mounting on display and housing bezel

(1) In all cases, the T/P should be supported from the backside of the Plastic.

(2) Do not to use an adhesive-tape to bond it on the front of T/P and hang it to the housing bezel.

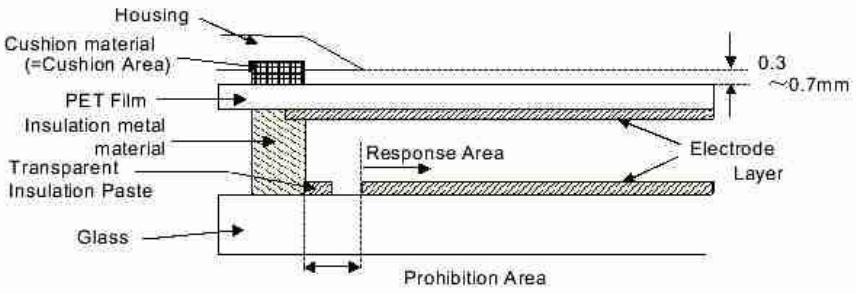
(3) Never expand the T/P top layer (PET-film) like a balloon by internal air pressure.

The life of the T/P will be extremely short.

(4) Top layer, PET, dimension is changing with environmental temperature and humidity.

Avoid a stress from housing bezel to top layer, because it may cause "waving".

(5) The input to the Touch panel sometimes distorts touch panel itself.



12. Handling of modules

12-1 Inserting the FPC into its connector and pulling it out.

- □ Be sure to turn off the power supply and the signals when inserting or disconnecting the cable.
- □ Please insert for too much stress not to join FPC in the case of insertion of FPC.

12-2 About handling of FPC

- □ The bending radius of the FPC should be more than 1.4mm, and it should be bent evenly.
- □ Do not dangle the LCD module by holding the FPC, or do not give any stress to it.

12-3 Mounting of the module

- □ The module should be held on to the plain surface. Do not give any warping or twisting stress to the module.
- □ Please consider that GND can ground a modular metal portion etc. so that static electricity is not charged to a module.

12-4 Cautions in assembly / Handling pre cautions.

As the polarizer can be easily scratched, be most careful in handling it.

□ Work environments in assembly.

Working under the following environments is desirable:

a) Implement more than 1MΩ conductive treatment (by placing a conductive mat or applying Conductive paint) on the floor or tiles.

b) No dusts come in to the working room. Place an adhesive, anti-dust mat at the entrance of the room.

c) Humidity of 50～70% and temperature of 15～27°C are desirable.

d) All workers wear conductive shoes, conductive clothes, conductive fingerstalls and grounding belts without fail.

e) Use a blower for electrostatic removal. Set it in a direction slightly tilt downward so that each Module can be well subjected to its wind. Set the blower at an optimum distance between the blower and the module.

□ How the remove dust on the polarizer

a) Blow out dust by the use of an N2 blower with antistatic measures taken. Use of an ionized air Gun is recommendable.

b) When the panel surface is soiled, wipe it with soft cloth.

□ In the case of the module's metal part (shield case) is stained, wipe it with a piece of dry, soft cloth. If rather difficult, give a breath on the metal part to clean better.

□ If water dropped, etc. remains stuck on the polarizer for a long time, it is apt to get discolored or cause stains. Wipe it immediately.

□ As a glass substrate is used for the TFT-LCD panel, if it is dropped on the floor or hit by something hard, it may be broken or chipped off.

□ Since CMOS LSI is used in this module, take care of static electricity and take the human earth into consideration when handling.

12-5 Others

□ Regarding storage of LCD modules, avoid storing them at direct sunlight-situation.
You are requested to store under the following conditions:
(Environmental conditions of temperature/humidity for storage)

(1) Temperature: 0~40°C

(2) Relative humidity : 95% or less

- As average values of environments (temperature and humidity) for storing, use the following control guidelines:
  Summer season: 20~35°C, 85% or less Winter season: 5~15°C, 85% or less
- If stored under the conditions of 40°C and 95% RH, cumulative time of storage must be less than 240 hours.

□ If stored at temperatures below the rated values, the inner liquid crystal may freeze, causing cell destruction. At temperatures exceeding the rated values for storage, the liquid crystal may become isotropic liquid, making it no longer possible to come back to its original state in some cases.

□ If the LCD is broken, do not drink liquid crystal in the mouth. If the liquid crystal adheres to a hand or foot or to clothes, immediately cleanse it with soap.

□ If a water drop or dust adheres to the polarizer, it is apt to cause deterioration. Wipe it immediately.

□ Be sure to observe other caution items for ordinary electronic parts and components.

13. Delivery Form

13-1. Carton storage conditions

1) Carton piling-up: Max 8 rows

2) Environments
Temperature: 0~40°C
Humidity: 65% RH or less (at 40°C)
There should be no dew condensation even at a low temperature and high humidity.

3) Packing form: As shown in Figure 4.
□ Cartons are weak against damp, and they are apt to be smashed easily due to the compressive pressure applied when piled up. The above environmental conditions of temperature and humidity are set in consideration of reasonable pile-up for storage.

13-2. Packing composition

Name	quantity	Note
Carton size	1	575×360×225 (mm)
Tray	12	Material: Electrification prevention polypropylene
(The number of Module)		8 unit/tray: 80 unit/carton
Electrification prevention bag	2	Material: Electrification prevention polyethylene 680mm(length)×500mm(depth)×50μm(thin)

Carton weight (80 modules): Approx. 9.2 kg

14. Reliability test items

No.	Test item	Conditions
1	High temperature storage test	Ta = +85°C 240h
2	Low temperature storage test	Ta = -30°C 240h
3	High temperature & high humidity operation test	Ta = +40°C ; 95%RH 240h (No condensation)
4	High temperature operation test	Ta = +70°C 240h (The panel temp. must be less than 50°C)
5	Low temperature operation test	Ta = -10°C 240h
6	Vibration test (non- operating)	Frequency : 10～55Hz/Vibration width (one side) : 1.5mm Sweep time : 1minutes Test period : (2 hours for each direction of X,Y,Z)
7	Shock test	Direction: ±X, ±Y, ±Z, Time: Third for each direction. Impact value : 100G Action time 6ms
8	Thermal shock test	Ta=-25°C～80°C /10 cycles (30 min) (30min)
9	Electro static discharge test	±200V·200pF(0Ω) to Terminals(Contact) (1 time for each terminals) ± 8kV· 150pF(330Ω) to Housing bezel or T/P(Contact) ± 15kV· 150pF(330Ω) to Housing bezel or T/P(in Air)
10	Point activation test (Touch panel)	Hit it 1,000,000 times with a silicon rubber of R8 HS 60. Hitting force :2.4N Hitting speed : 3 times per second
11	Writing friction resistance test (Touch panel)	Slide Pen 100,000 times under following conditions: Pen: 0.8Rmm Placental stylus Load: 2.4N Speed: 3 strokes per second Stroke: 30mm Testing apparatus: shown in Fig (I)
12	FPC Bending Test	Bending 30 times by bending radius R0.6mm and angle=90°(LCD FPC, T/P FPC)

【 Note】 Ta = Ambient temperature

【 Check items】

(a)Test No.1～9

In the standard condition, there shall be no practical problems that may affect the display function.

(b)Test No.10～No.11

The measurements after the tests are satisfied Touch panel characteristics.

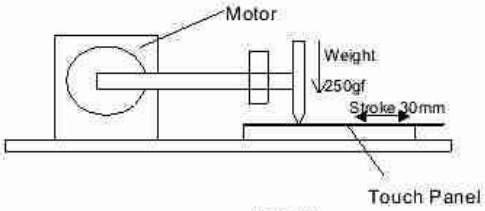


Fig.(I)

【 Result Evaluation Criteria】

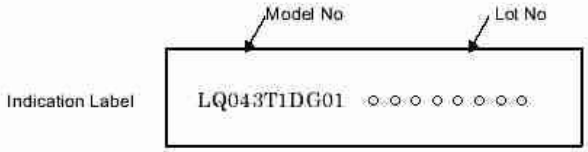
Under the display quality test conditions with normal operation state, these shall be no change which may affect practical display function.

15. Display Grade

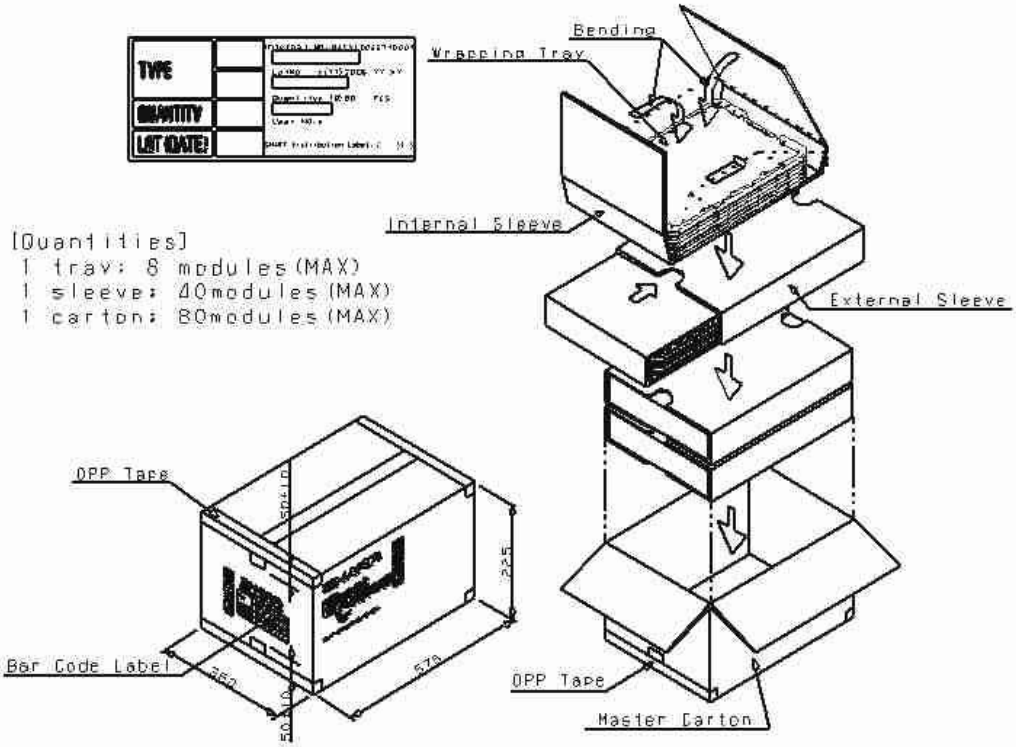
The standard regarding the grade of color LCD displaying modules should be based on the delivery inspection standard.

16. Lot No. marking

The lot No. will be indicated on individual labels. The location is as shown



17. LCD module packing carton



18. Others

1 Disassembling the module can cause permanent damage and you should be strictly avoided.

2 Please be careful that you don't keep the screen displayed fixed pattern image for a long time, since retention may occur.

3 If you pressed down a liquid crystal display screen with your finger and so on, the alignment disorder of liquid crystal will occur. And then it will become display fault.
Therefore, be careful not to touch the screen directly, and to consider not stressing to it.

4 If any problem arises regarding the items mentioned in this specification sheet or otherwise, it should be discussed and settled mutually in a good faith for remedy and/or improvement.

19. Outline dimension

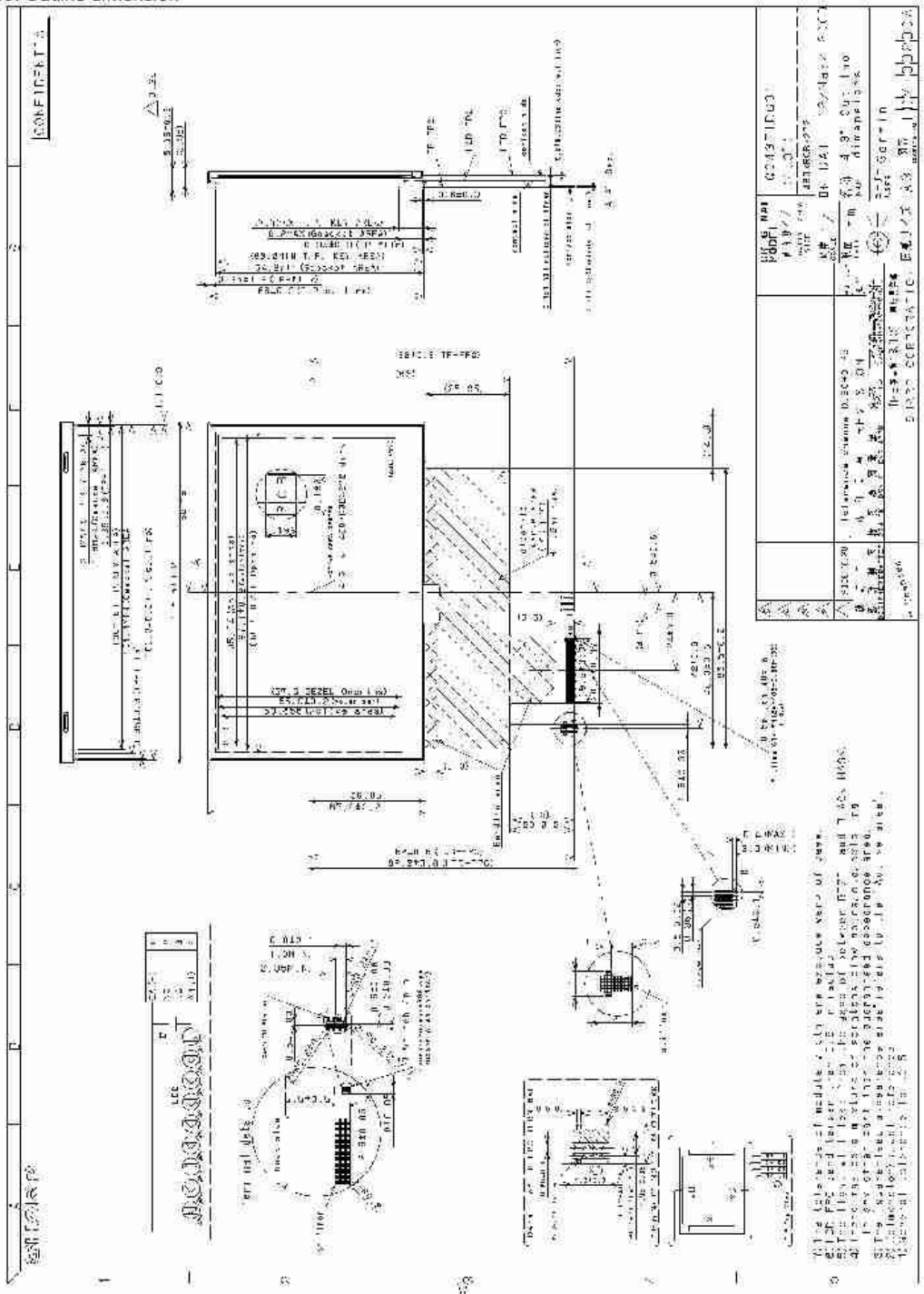


Fig.1

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SHARP

NORTH AMERICA

SHARP Microelectronics of the Americas
5700 NW Pacific Rim Blvd.
Camas, WA 98607, U.S.A.
Phone: (1) 360-834-2500
Fax: (1) 360-834-8903
Fast Info: (1) 800-833-9437
www.sharpsma.com

EUROPE

SHARP Microelectronics Europe
Division of Sharp Electronics (Europe) GmbH
Sonninstrasse 3
20097 Hamburg, Germany
Phone: (49) 40-2376-2286
Fax: (49) 40-2376-2232
www.sharpsme.com

JAPAN

SHARP Corporation
Electronic Components & Devices
22-22 Nagaike-cho, Abeno-Ku
Osaka 545-8522, Japan
Phone: (81) 6-6621-1221
Fax: (81) 6117-725300/6117-725301
www.sharp-world.com

TAIWAN

SHARP Electronic Components
(Taiwan) Corporation
8F-A, No. 16, Sec. 4, Nanking E. Rd.
Taipei, Taiwan, Republic of China
Phone: (886) 2-2577-7341
Fax: (886) 2-2577-7326/2-2577-7328

SINGAPORE

SHARP Electronics (Singapore) PTE., Ltd.
438A, Alexandra Road, #05-01/02
Alexandra Technopark,
Singapore 119967
Phone: (65) 271-3566
Fax: (65) 271-3855

KOREA

SHARP Electronic Components
(Korea) Corporation
RM 501 Geosung B/D, 541
Dohwa-dong, Mapo-ku
Seoul 121-701, Korea
Phone: (82) 2-711-5813 – 8
Fax: (82) 2-711-5819

CHINA

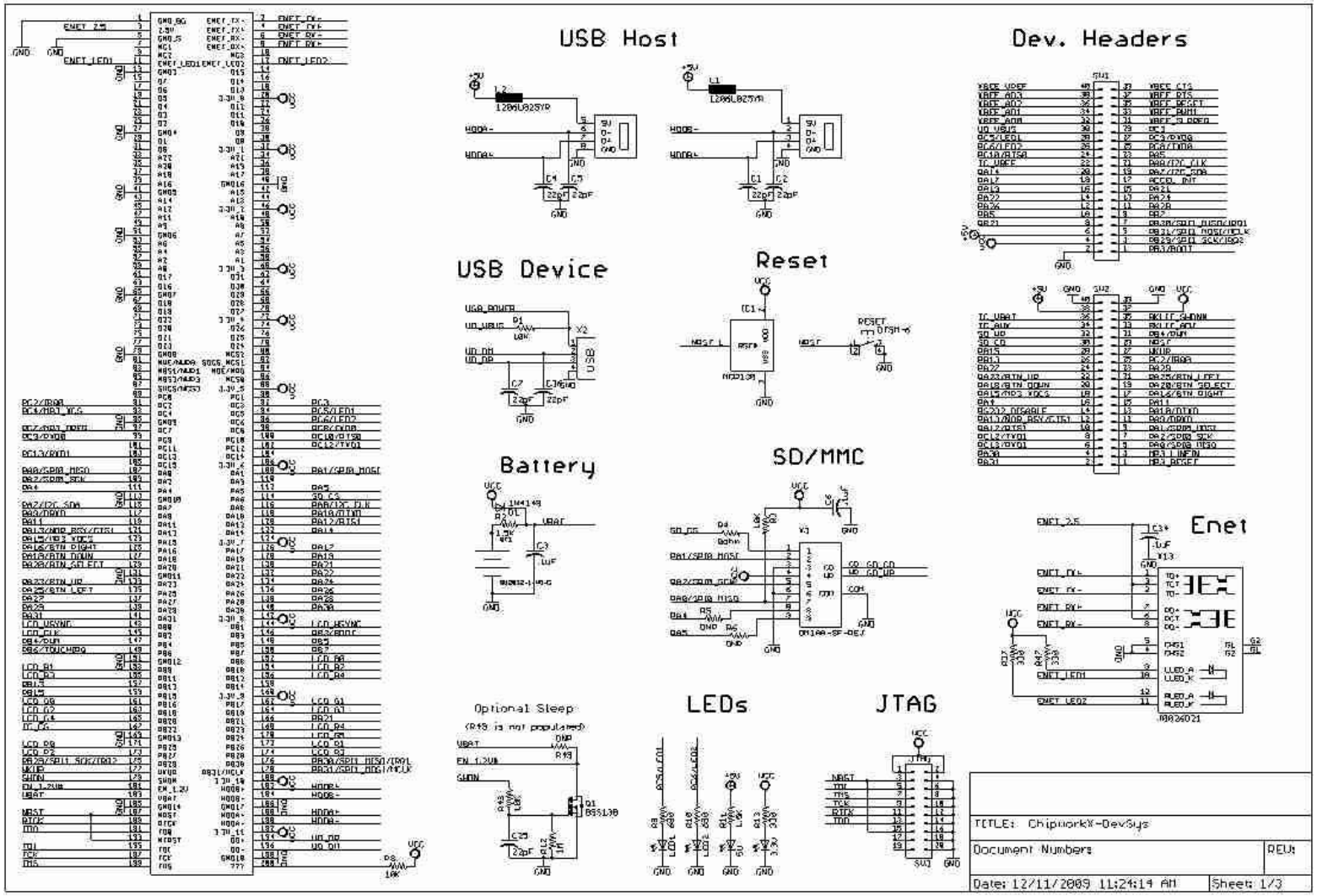
SHARP Microelectronics of China
(Shanghai) Co., Ltd.
28 Xin Jin Qiao Road King Tower 16F
Pudong Shanghai, 201206 P.R. China
Phone: (86) 21-5854-7710/21-5834-6056
Fax: (86) 21-5854-4340/21-5834-6057
Head Office:
No. 360, Bashen Road,
Xin Development Bldg. 22
Waigaoqiao Free Trade Zone Shanghai
200131 P.R. China
Email: smc@china.global.sharp.co.jp

HONG KONG

SHARP-ROXY (Hong Kong) Ltd.
3rd Business Division,
17/F, Admiralty Centre, Tower 1
18 Harcourt Road, Hong Kong
Phone: (852) 28229311
Fax: (852) 28660779
www.sharp.com.hk
Shenzhen Representative Office:
Room 13B1, Tower C,
Electronics Science & Technology Building
Shen Nan Zhong Road
Shenzhen, P.R. China
Phone: (86) 755-3273731
Fax: (86) 755-3273735

APPENDIX D

ChipworX Development System Schematic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Reset
Battery
SD/MMC
Enet
Optional Sleep
(R49 is not populated)
LEDs
JTAG
TITLE: ChipworkX-DevSys
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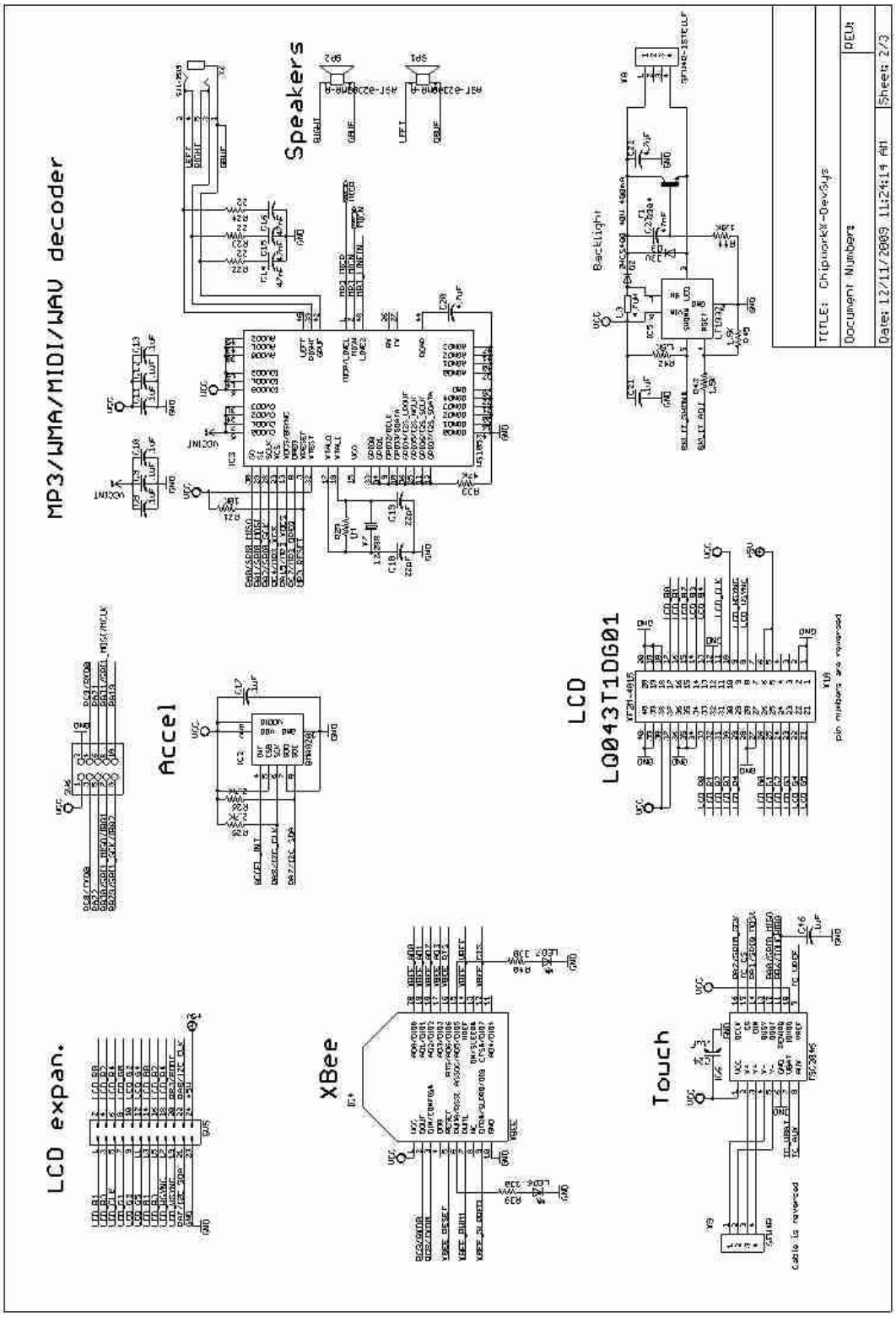
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Speakers
Backlight
LCD
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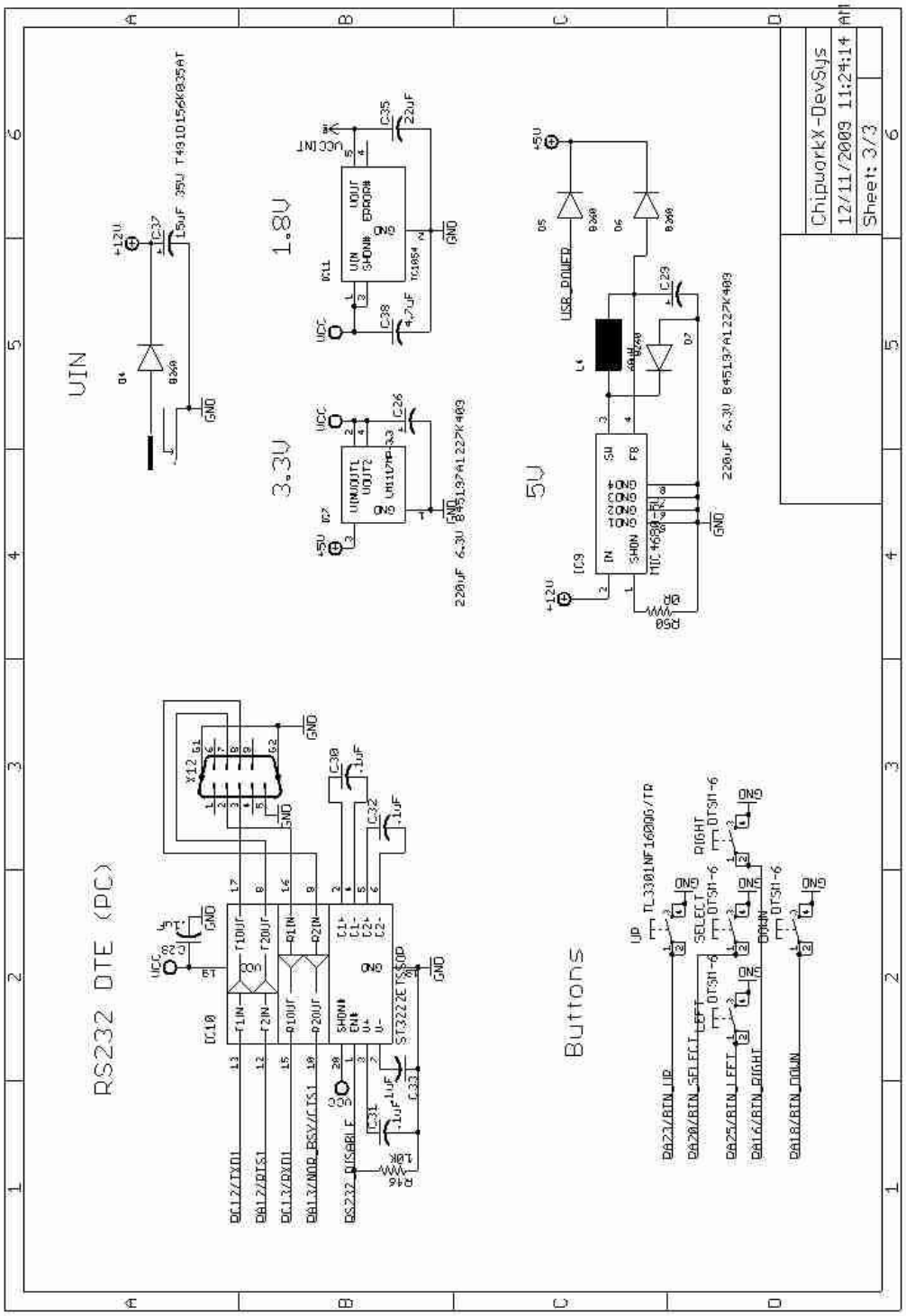
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3.3V
5V
RS232 DTE (PC)
Buttons
ChipworkX-DevSys
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